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Monthly Profit and Loss Accounts.

A SIMPLE SYSTEM EXPLAINED.

By A. WINDER.

THE path of the engineering Cost-accountant is beset with many and considerable difficulties, and no doubt many abortive attempts have been made to overcome these difficulties and to formulate and maintain systems of costings which would at once reveal the costs of manufactured articles and show periodically the net result of the trading. These failures have been due chiefly to the assumption that it is necessary to show on a cost sheet the absolute cost of the article to which it relates. A little consideration will show, however, that such a form of cost sheet is not the most desirable. Such a system involves delay in the completing of the costings, because it is necessary to ascertain at the end of the month exactly what has been the cost of running the Establishment, and the rate per cent. on Productive Wages to be consequently charged to Costings for "Establishment Oncost."

One of the essential features of the system presently explained is that a fixed rate per cent. is always charged against costings for Establishment Oncost. Any difference there may be between the amount thus charged during the month, and the actual cost of the Establishment, is passed into the Profit and Loss Account. This method offers the following advantages, namely: that costings can be completed without delay, costs of similar goods can be compared on a common basis, the efficiency of the shops is brought periodically under review by means of the "Establishment" or "Maintenance" Account, and the results obtained can readily be compared with the ordinary account books and thereby proved.

This system is in use at the works of a well-known firm of high-speed planing machine manufacturers. When inaugurating it the author found much valuable material ready to hand. For instance, each Establishment account (Power, Lighting, Heating, Smithy, Office, Selling, &c.), besides every "Productive Job" going through the shops,

had a "working number," and all goods specially ordered for any of these were so designated by the working No. in the order books. This facilitated the analysis of invoices. Similarly, all goods issued from Stores were issued against Requisition Notes made out by the foremen, and those notes bore invariably the Working Number. Again, a system of Time Cards was in use, and on all these cards appeared the Working Number. It was not found necessary to alter these three things, for the Working Numbers made it easy to analyse the purchases, the wages and the stores-issues. To the Working

ANALYSES BOOK.

Note.—Transfers are best dealt with through the stores column. Debits in green, credits in red.

Account.	W/n.	Materials and Sundry.									Wages.			Total of M. and W.		
		Issued by Stores.			Cash Book.			Purchase Book.			Totals.					
		£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
PRODUCTIVES:—																
(Speciality)	A 355 ...	7	0	0	1	0	0	2	0	0	10	0	0	5	0	0
	A 338 ...	20	0	0	—			—			20	0	0	—		
	A 360 ...	—			—			20	0	0	20	0	0	151	0	0
	A 361 ...	81	0	0	—			19	0	0	100	0	0	—		
	A 372 ...	200	0	0	—			—			200	0	0	—		
	A 373 ...	200	0	0	—			100	0	0	300	0	0	—		
	A 374 ...	200	0	0	—			150	0	0	350	0	0	344	0	0
	Totals ...	708	0	0	1	0	0	291	0	0	1000	0	0	500	0	0
(General)	G 356 ...	—			—			—			—			0	10	0
	G 357 ...	—			—			—			—			3	0	0
	G 365 ...	10	0	0	—			—			10	0	0	40	0	0
	G 375 ...	50	0	0	—			40	0	0	90	0	0	56	10	0
	Totals ...	60	0	0	—			40	0	0	100	0	0	100	0	0
(Stores)	S 359 ...	—			2	0	0	16	0	0	18	0	0	7	0	0
	S 370 ...	—			—			10	0	0	10	0	0	10	0	0
	S 371 ...	—			—			2	0	0	2	0	0	3	0	0
	Sundry ...	—			—			570	0	0	570	0	0	—		
	Totals ...	—			2	0	0	598	0	0	600	0	0	20	0	0
(Capital)	C 354 ...	9	0	0	—			—			9	0	0	2	0	0
	C 358 ...	—			—			1	0	0	1	0	0	—		
	Totals ...	9	0	0	—			1	0	0	10	0	0	2	0	0
MAINTENANCE:—																
	Machines..	—			—			1	0	0	1	0	0	9	0	0	10	0	0
	Power ...	—			2	0	0	—			2	0	0	1	0	0	3	0	0
	Tools ...	20	0	0	—			—			20	0	0	20	0	0	40	0	0
	Buildings..	—			1	0	0	—			1	0	0	—			1	0	0
	Drawings and patts.	—			—			3	0	0	3	0	0	33	0	0	36	0	0
	Offices ...	—			—			—			—			160	0	0	160	0	0
	Sundry ...	3	0	0	—			—			3	0	0	160	0	0	163	0	0
	Totals ...	23	0	0	3	0	0	4	0	0	30	0	0	383	0	0	413	0	0
DEAD CHARGES:—		—			—			6	0	0	6	0	0	—		
Totals, agreed with various books		800	0	0	6	0	0	940	0	0	1746	0	0	1005	0	0

COST LEDGER.

Date.	A. 355. One 36 ins. × 36 ins. × 10 ft. planer for o/3120.		G 356. One special fly wheel o/3120.		G 357. Two special heavy pulleys 24 ins. × 7 ins. × 3 ins. o/3120.		C 358. Portable drill outfit for erecting shop. o/(selves).		S 359. 12 type C. gear boxes. o/Stores 122.		A 360. One 72 ins. × 72 ins. × 20 ft. planer for o/3142.	
1907.	M.	W.	M.	W.	M.	W.	M	W.	M.	W.	M.	W.
Jan. 1	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.		£ s. d.	£ s. d.	£ s. d.	£ s. d.
Stocks on hand	100 0 0	100 0 0	1 0 0	0 10 0	2 0 0				14 0 0	2 0 0	210 0 0	50 0 0
Jan.	10 0 0	5 0 0		0 10 0		3 0 0	1 0 0		18 0 0	7 0 0	20 0 0	151 0 0
	110 0 0	105 0 0	1 0 0	1 0 0	2 0 0	3 0 0						
	Despatched Jan. 15/07. Inv. No. 619.		Despatched Jan. 15/07. Inv. No. 619.		Despatched Jan. 15/07. Inv. No. 619.							

Numbers, however, were prefixed letters with a view to defining the job as belonging to some "Productive," "Capital," or "Maintenance" account, and facilitating the subsequent operations.

An "Analyses" book was opened, and in this all analyses were entered each month. The accompanying ruling illustrates the book, and the examples given will clearly demonstrate how easily the following Trading Account is written up. Instead of separate analyses in the Wages, Petty-cash, Purchases, and Stores-issues Books, we have the various analyses in concise form in one book.

The simplest form of Cost Ledger, of

SALES AND STOCK SUMMARY.

	Sale.	Net Cost.			Cost with Establishment (100 %).			* Stocks and Produced.	Stocks left.
		Mtl.	Lab.	Total.	Mtl.	Lab. +100 %.	Total.		
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Specialty ...	2,600 0 0	1,250 0 0	600 0 0	1,850 0 0	1,250 0 0	1,200 0 0	2,450 0 0	6,000 0 0	3,550 0 0
General... ...	60 0 0	36 0 0	37 0 0	43 0 0	36 0 0	14 0 0	50 0 0	800 0 0	750 0 0
Stores	105 0 0	98 0 0	1 0 0	99 0 0	98 0 0	2 0 0	100 0 0	1,340 0 0	1,240 0 0
	2,765 0 0	1,384 0 0	608 0 0	1,992 0 0	1,384 0 0	1,216 0 0	2,600 0 0	8,140 0 0	5,540 0 0
Scrap	15 0 0								
Sundry	3 0 0								
	2,783 0 0								

* See "S" in Trading Account. Stores-issues, £800 is deducted from the £2,140.

which a ruling is shown, is written up from the Analyses Book.

The cost in material and wages of all goods sold during the month is taken from this Cost Ledger and is tabulated, along with the Sales analysis, in the concise form shown.

The Analyses Book and the Sales and Cost Summary provide all the necessary data for the compilation of the Trading

TRADING ACCOUNT FOR JANUARY (28 DAYS TO FEB. 1), 1907.

		£ s. d.			£ s. d.
Specialty No. 1—			Sales	E	2,600 0 0
Stock, Jan. 1st	A	4,000 0 0	Finishing stocks	Aa	3.550 0 0
Purchases	B	1,000 0 0			
Wages	C	500 0 0			
Establishment 100 per cent	D	500 0 0			
	S	6,000 0 0			6,150 0 0
Balance (profit)		150 0 0	Balance (loss)		—
		6,150 0 0			6,150 0 0
General Jobs—					
Stocks, Jan. 1st	A	500 0 0	Sales	E	60 0 0
Purchases	B	100 0 0	Finishing stocks	Aa	750 0 0
Wages	C	100 0 0			
Establishment 100 per cent	D	100 0 0			
	S	800 0 0			810 0 0
Balance (profit)		10 0 0	Balance (loss)		—
		810 0 0			810 0 0
Stores—					
Stocks, Jan. 1st	A	1,500 0 0	Stores-issues	F	800 0 0
Purchases	B	600 0 0	Sales	E	105 0 0
Wages	C	20 0 0	Finishing stocks	Aa	1,240 0 0
Establishment 100 per cent	D	20 0 0			
	S	2,140 0 0			2,145 0 0
Balance (profit)		5 0 0	Balance (loss)		—
		2,145 0 0			2.145 0 0
Capital account—					
Purchases	B	10 0 0	Capital Account		14 0 0
Wages	C	2 0 0			
Establishment 100 per cent	D	2 0 0			
		14 0 0			14 0 0
Establishment account—			"D" debits, contra,		
Maintenance of machines	B&C	10 0 0	Brought down ... £500 0 0		
Power account	,,	3 0 0	100 0 0		
Tools	,,	40 0 0	20 0 0		
Buildings	,,	1 0 0	2 0 0		
Drawings and patterns	,,	9 0 0			H 622 0 9
Offices	,,	200 0 0	Sundry sales	E	3 0 0
Sundry	,,	150 0 0			
		413 0 0			
Power—gas and water (from meter readings)		34 0 0			
Proportion of dead charges, 28 days at £7 ...	G	196 0 0			625 0 0
			Balance (loss)		18 0 0
		£643 0 0			£643 0 0

PROFIT AND LOSS ACCOUNT.

	£	s.	d.		£	s.	d.
Loss on establishment account...	18	0	0	Profit on Specialty No. 1 ...	150	0	0
Discounts allowed, CB/F 94 K	30	0	0	,, ,, General Jobs	10	0	0
				,, ,, Stores	5	0	0
				Discounts obtained CB/F 95 K	15	0	0
				Scrap sold... I	15	0	0
Balance	147	0	0				
	195	0	0		195	0	0
				Balance down	£147	0	0

Account, which will now be explained in detail, the examples being based on the following assumption:—

That it has been decided to keep separate accounts—

For our Specialty,

For General Jobs,

For Stores,

For Capital account, and

For Establishment or Maintenance account (in detail);

Further, that stock has been taken and analysed in agreement with these accounts; and, lastly, that our expenses of maintenance last year were approximately equal to 100 per cent. of the amount paid in "productive" wages, so that 100 per cent. will be a sufficient charge to make for establishment oncost.

A. The commencing stocks the first month in the new year are taken from the stock-taking summary, but in subsequent months the finishing stocks of the previous month (Aa) become the commencing stock.

B. The term "purchases" is necessarily elastic. It comprises all expenditure other than wages and may include outside labour, carriage or other expenditure incurred specially for the account. The amount is taken from the Analyses Book.

C. The amount of wages spent on the account is next entered, and is, like "purchases," obtained from the Analyses Book.

D. The account is next debited with its share of Establishment expenses at a fixed rate per cent. on the productive wages. In our example we have taken this as being 100 per cent. on the productive wages, and the amount is therefore equal to the debit for wages.

E. The value of the goods invoiced on the account is entered on the credit side.

Aa. The value of the finishing stocks is quickly found from the sales and costs summary. If no goods had been sold on the account during the month, it is obvious that the cost of the finishing stock would have been equal to the total debits, namely, £6,000. But, as a matter of fact, goods costing £2,450 have been sent out, and the cost of the remainder, £3,550, represents the value of the finishing stocks.

The difference between the two sides is profit or loss, as the case may be. In our example the "specialty" account shows a profit of £150, which is carried to the credit of the Profit and Loss account.

F. In the stores account the equivalent to Sales is "Stores-issues," the total value of which, as obtained from the Analyses Book, is credited to the proper section of the Trading Account. There may, however, sometimes be goods actually sold direct from Stores at a profit or loss. In the example we show such a sale and a little profit.

Establishment Account. — The Analyses Book is again called into service in the compilation of this account. To the direct expenditure in repairs and maintenance have to be added the liability incurred for electric current, gas and water, if these are bought. This liability is easily found by means of the meter readings.

G. There are certain other Dead, Standing or Fixed expenses which do not come monthly through the accounts. These are such items as Rent, Interest, Rates, Insurance, Depreciation, Salaries, Directors' Fees and Patent Fees. The total annual charge under this head is divided over the twelve months *pro rata* to the number of actual working days in the month.*

H. The various amounts which have been debited to the productive and capital accounts for Establishment On-cost (see letters D) are placed to the credit of the Establishment account along with any sundry sales, and the balance on the account is, as in the case of the other accounts, passed into the Profit and Loss Account.

* The months are made up to the pay day nearest the last day of the month, and consequently consist of four or five weeks, there being eight months of four weeks and four of five weeks in the year. This method makes it easy to agree the total of the time cards with the wages book. If for some *known* reason there should be a difference between the sum of the wages debited to accounts (Analyses Book) and the wages actually paid, the difference should be carried to the Profit and Loss Account.

The Profit and Loss Account requires but little explanation. Most of the items are brought down from the Trading Account, there being only two items which are obtained from other sources. These are:—

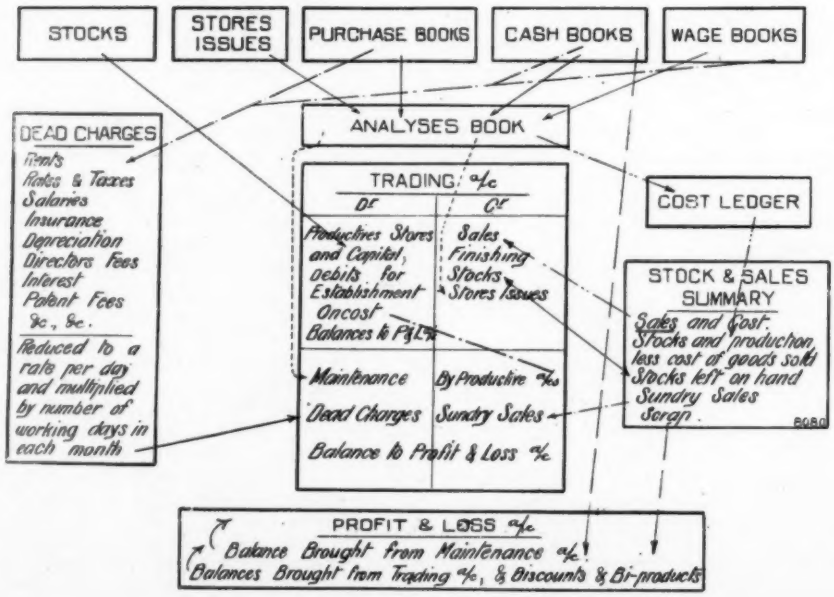
I. Scrap, or By-products. This figure may be obtained in either of the following ways:—

(*a*) By an estimate of the value of such goods made during the month; in cases where sales or transfers to the foundry are not made with regularity, or

(*b*) By taking the value of such goods invoiced out during the month, or transferred to the foundry. Provided such goods are disposed of with sufficient regularity, this means is much to be preferred on considerations of simplicity and reliability.

K. Discounts, as revealed by the Cash Books.

As will have been gathered by the foregoing remarks, the difference



between the two sides of the Profit and Loss Account is either the net profit available for dividend or the net loss on the month's working.

The diagram opposite is added by way of graphically demonstrating the working of the system, which the author hopes will prove not only interesting but also helpful to readers who are desirous of constructing a system suited to their own particular requirements.

The Pattern-Shop and Foundry in Machine Design.

THE pattern-shop and foundry of an Engineering Works invariably contain important principles which are frequently overlooked by the constructive draughtsman engaged in the rougher forms of millright work, or the more intricate and artistic designs of engines and machine tools. This is largely due to the majority of draughtsmen having but a limited knowledge of both pattern-making and moulding, and which at times lead them into difficulties with both departments. The foreman of the first-named must necessarily point out the difficulty, and may often suggest a modification in order to meet the exigencies of the pattern-shop or foundry.

To introduce economy and simplification in design would at times present a very difficult problem, but with keen competition it is essential that the cost of pattern-making should be carefully studied, and extra work in the foundry avoided as far as possible.

The design of a machine is not always destroyed by modification, yet it does not follow that everything must be reduced to severe plainess, in order to meet the requirements of pattern-shop and foundry. Commencing with the pattern-shop, we find in the majority of cases where patterns are without core-boxes as in millwright fixings, the thickness of metal as given on the drawing governs the thickness of timber to be used in constructing the pattern.

This may be a dimension which falls in conveniently with the timber. Then the economy is at once apparent; where if on the other hand it fails to do so, then an excessive amount of sawing and planing will have to be done, and which would have been saved by a little knowledge relative to the thicknesses and general sizes of timber as used in the pattern-shop. A simple form of bracket illustrates a case in point, the dimension $\frac{9}{16}$ in. being the thickness of metal throughout.

This means that $\frac{3}{4}$ in. timber would be too thin, being only $\frac{5}{8}$ in. thick, or what is termed $\frac{3}{4}$ in. off the saw,

The pattern-maker is therefore compelled to use the next thickness, viz., $\frac{7}{8}$ in., or 1 in. and remove the superfluous amount. The extra labour could have been avoided by a little increase in width, or by the introduction of a few brackets, and the casting would have been equally strong, if not stronger, than if thicker metal had been substituted.

The introduction of long bosses are frequently a source of trouble, inasmuch as special provision must be made to ensure their release from the mould.

Dimensions on drawings should be kept within reasonable limits, and when decimal measurement is used the fractions need not extend beyond two places,

as, for example, ·3125 or ·5625 will be quite as good for the constructural purposes of the pattern if the two last figures in each fraction are omitted.

A very obvious loss of time is entailed in following out dimensions the same as the ones quoted, unless a rapid transposition can be effected, or some common sense brought to bear by substituting an equivalent which is near enough for all practical purposes.

Curves on drawings are very rarely dimensioned, and are often put in with what is known as a French curve.

The latter cannot be easily re-produced, and curves of given dimensions formed by the intersection of lines are far preferable, because they are more practicable and more easily enlarged to full size from scale drawings.

Perhaps by far the most important is the simplification of design which reduces the difficulties of moulding.

How often do we find jobs sent into the foundry which require special appliances before they can be satisfactorily moulded. This in many cases is consequent upon the draughtsman introducing difficulties which he would have certainly eliminated had his knowledge of moulding and foundry practice been commensurate with that of machine construction or applied mechanics.

The awkward problems of moulding are almost invariably dealt with in the pattern-shop, but this generally means an interference with design, which is not always appreciated.

It is therefore advisable to even consult the foreman pattern-maker on occasions where some peculiar form may be necessary, and he may suggest some slight alteration, but with a knowledge of moulding the draughtsman would have produced something practicable, and of such form that an appeal to either pattern-shop or foundry would have been unnecessary.

A very great source of trouble is the frequent omission of sections, which would be of infinite use to the pattern-maker for reference, but which are omitted because they are deemed of no use to the other departments. Sections, however, are very necessary, and should at all times be given, as they often determine points in the construction and disposition of the timber, and further in arranging the method of making and moulding of the pattern. The rounding of corners and the correct contour of the pattern should be shown on all drawings sent into the pattern-shop. These are two factors which are somewhat neglected, as it is assumed that the pattern-maker will know how to finish off this section into that, or how much convexity should be given on the bases of a machine-tool which is indicated on the drawing by a straight line.

These shortcomings place the pattern-maker at a great disadvantage inasmuch that he has frequently to alter the pattern after it has been sand-papered and finished. It is often argued that the lines necessary to convey the exact details of design cannot be shown on the drawing; if this be admissible, then the pattern might be sent into the foundry with the same shallow pretext that it does not represent the precise form of the mould.

Rounded corners serve a two-fold purpose, firstly in giving a finish to the sharp edges and improving the contour, and secondly assisting in the more important function of distributing the metallic crystals in their proper order during the period of cooling.

At this point something may be said relative to the importance of rounded corners and fillets in both patterns and core-boxes. The primary object of filleting or cornering a pattern is to prevent the sinking of the casting at the junction of the angles, this effect being brought about by the shrinking strains or by the segregation of the iron or other metal. If the filleting of the casting be left to the moulder, it invariably follows that no two corners are alike, nor can we expect their outline to be anything like symmetrical. This is particularly so in the case of fillets which have been formed in a vertical direction, as they are sometimes difficult to reach and at the same time are a source of trouble, consequent upon the

sand which is being pared away falling to the bottom of the mould.

Small portions of this, if left, might fail to emerge through the riser, with the result that some corner of the casting would be minus or honey-combed with the floated sand. There is, of course, less trouble in making horizontal corners to form fillets, these being usually "sleeked" or pressed down by the moulder's smoother.

Corners and fillets in core-boxes are very often omitted, although it must be pointed out that they are just as necessary and essential to the production of a good casting as any finish given to the exterior.

They are, however, neglected, and though they help to strengthen the casting and resist the shrinkage strains, they are often dependent for their existence on the core-maker's trowel. Further, well-rounded and filleted corners on a pattern offer an easier withdrawal from the sand, and after the casting is made, the dressing operation is more easily accomplished than if the corners and junctions were all left sharp. Those in touch with various classes of machinery, must have frequently noticed the many omissions in design, which have marred the symmetry and detracted from what, with a little more care, would have been a well proportioned machine. Without a desire to make invidious comparison or introduce ornate design, it may be said that the greatest offenders are the builders of machine tools and stationary engines.

The former are mostly inclined to dispose the metal in unsuitable proportions, particularly in the bodies and vertical uprights which usually represent the principal features of a machine tool.

A conspicuous feature in the cross-slides of both planers and boring mills, is an absence of stiffness, which might have been easily obviated by the introduction of a fish-back net or a bridge form of backing.

Either of these give considerable rigidity to the casting and a decided improvement in appearance with very little additional weight.

In the vertical uprights, the bases are often deficient both in length and width, the reduction of surface giving the piece the semblance of being top-heavy.

The inequality of metal—at times unavoidable—has a tendency to bring about defective castings by robbing the thinner sections, leaving sunken places on the sides and wavy edges on the ribs and flanges, with lines of weakness running through the casting, between the coarser and finer grain of the heavier and lighter sections. A more intensified form of this weakness is shown when the castings are fractured at the juncture of a thick and thin section of metal.

Thus defective castings are sometimes, but not always, the fault of the moulder, but in cases where it is almost impossible to equalise the metal, some attention must be given in the foundry by assisting to minimise the initial stresses set up during the cooling of the metal. This may be done by placing "risers" in suitable positions on the mould, and "feeding" the casting until the metal becomes too stiff to continue the operation, and also by using judgment in "baring" certain parts of the casting to attain a more equable temperature throughout. A greater amount of strength, uniformity, and lightness can be often secured by coring out the heavier masses. Though the removal of the superfluous metal may mean something extra for pattern-making, it is more than compensated for by the sounder casting. Here we often find an absence of any provision in the design for dealing with the cores of the casting.

As is well known, it is necessary to carry off the gas generated in the mould, by the combustion of the coal dust and other compounds, and in order to do this both mould and cores must be thoroughly "vented."

It is therefore essential to a sound casting that perfect egress should be given to the gases, and this is only obtainable by making ample provision by a proper disposition of the exits. This, however, frequently encroaches on

the design by perforating—for instance—a wall of metal forming the interior of a casting.

It is well to confer with the draughtsman at this stage, and point out the suggested apertures, as the pattern-shop is not always conversant with the general arrangement of the machine parts, and holes which were not anticipated in the design might seriously interfere with other details. Designs for steel and aluminium castings should have particular attention given to them; in the first named every superfluous corner should be well rounded and all angles well filleted, and the minimum amount for boring allowed in all cored holes. Attention to these salient points will do much to ensure a uniform casting if, in addition, the metal is evenly proportioned; then we may expect a casting of equal hardness throughout by reason of having done everything necessary to assist the annealing of the same. Aluminum alloys are much in evidence as castings for textile work and are rapidly superseding brass and iron for metal patterns.

Its extreme lightness makes it specially suitable for patterns of large size, but the contraction allowance must be carefully measured, as the shrinkage from the wood pattern through aluminium to iron is about ·36, and to steel about ·46 per lineal foot. Pure aluminium, however, is not used for the purpose, but is alloyed with varying small percentages of copper, nickel and tungsten. This type of pattern is undoubtedly the best, and its initial cost is soon compensated—especially in repetition work—by the easier manipulation consequent upon its extreme lightness and the absence of shrinkage and twist natural to the wood pattern after long service. In concluding this article, it is not the object of the writer to trespass on shop management, but merely to point out some of the few points which are often neglected, and which would be conducive as a means to secure better results. Though we may never reach an ideal stage in the harmonising of the several departments of the shop, it is possible that by a vigilant attention to details and a more frequent interchange of ideas, much can be done to obviate superfluous work, weakness in design, and faulty castings.

These and many other annoyances are always inseparable from a conservatism, which precludes the heads of departments from consulting with one another to the mutual benefit of all concerned.

Some Engineering Features of the Brooklands Motor Track.

By W. NOBLE TWELVETREES, M.I.Mech.E.

APART from the interest excited among automobilists by the motor-racing track now nearing completion at Brooklands, the work embodies many features deserving the attention of engineers.

The idea of building this, the first track of the kind in the United Kingdom, originated with Mr. Locke King, of Brooklands, who, having had plans prepared by Colonel Holden and Mr. A. W. Donaldson, commenced to make clearings through the pine woods on his estate, and afterwards proceeded by somewhat primitive methods to lay out the course itself.

Progress was so slow that the proprietors entered into an agreement with Messrs. Price and Reeves, of Westminster, for completion of the work. The advent of this firm very quickly changed the aspect of affairs. Railway tracks were laid down, steam navvies, locomotives, and trucks made their appearance. A wide and deep cutting was rapidly made through wooded heights, and the soil was quickly transported to lower land for banking up the track to the requisite sûper-elevation. At the same time, the course of the River Wey was diverted into a newly-formed channel, and the foundations of

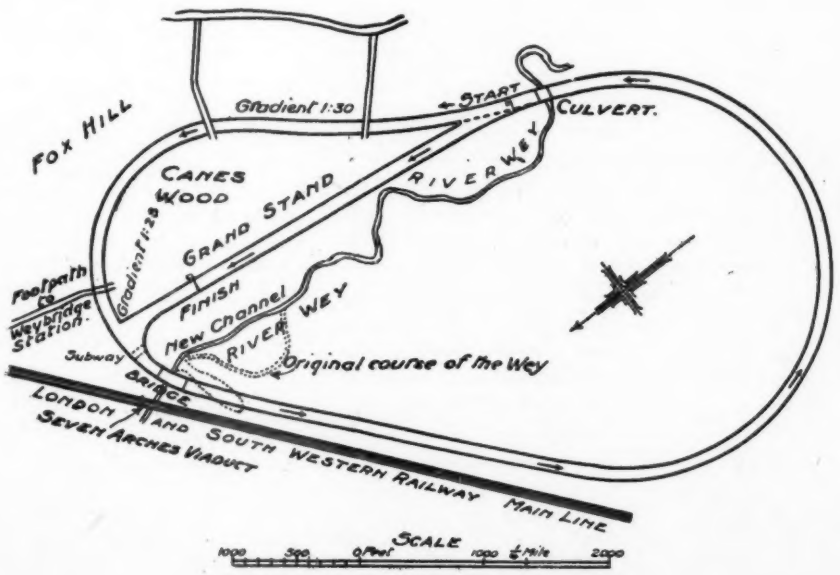


FIG. I.—BLOCK PLAN OF THE WEYBRIDGE MOTOR TRACK.

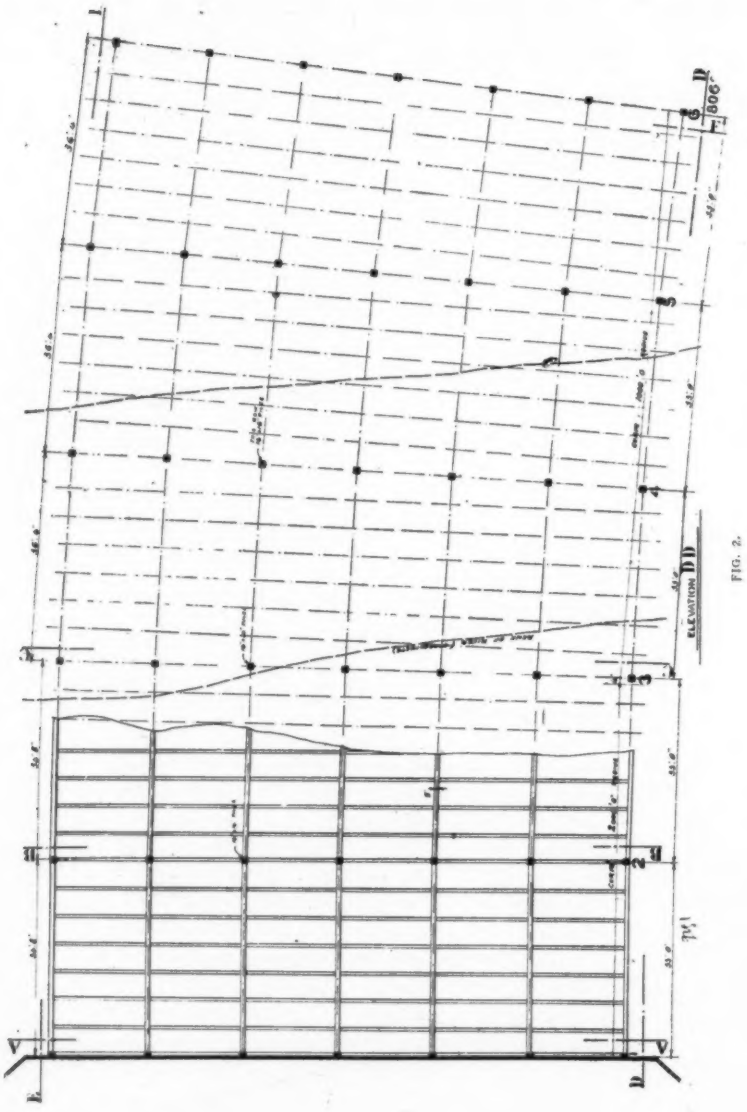


FIG. 2.

a concrete-steel bridge nearly 180 ft. long were laid to carry the track across the river.

Fig. 1 is a block plan, which will give readers a good general idea of the new track and its surroundings. In plan, the track is of ovoid form, with the circumference of nearly $2\frac{3}{4}$ miles and the uniform width of 100 ft., so as to permit from ten to twelve cars to run abreast without undue crowding. The starting point is on the south-east side, where a culvert has been built for conveying the waters of the River Wey beneath the track. Passing across the low-lying meadows which border the river, the course enters an up-gradient of 1 in 30 leading to the curve at the Weybridge end, whence level ground is reached by a down gradient of 1 in 25.

Notwithstanding these two gradients, the elevation of the land has made it necessary to carry the track round the curve in a deep cutting through the high ground known as Fox Hill, and consisting chiefly of Bagshot sand.

In descending from the high ground, the track draws near to the main line of the London and South-Western Railway crossing the River Wey over the Seven-Arch Viaduct, opposite to which is the new concrete-steel bridge carrying the track over the new channel of the same stream. A straight level stretch, about two-thirds of a mile long, is then entered leading to the curve at the other end of the course. This curve is also level and brings us back to the starting point, whence a straight level road about two-thirds of a mile in length branches off along the water meadows and joins the down-gradient from the north-eastern curve.

The finishing point is indicated in Fig. 1 by a small flag, and beyond it is a steep incline which will serve effectually to check the speed of cars to such an extent as to permit them to negotiate the corner where the straight road joins the outer circle of the track.

Including the straight run to the finishing point, the total length of the racecourse is $3\frac{1}{4}$ miles. As shown in Fig. 1, the grand stand will occupy the western slope of Fox Hill in front of Canes Wood. Thus the greater part of the track will be in full view of spectators, who will be able to watch the progress of races almost uninterruptedly from start to finish.

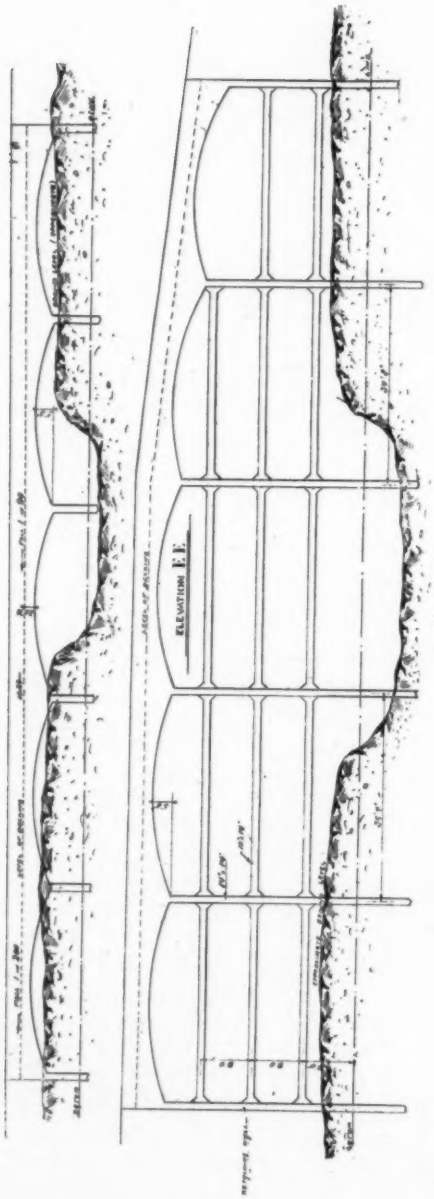
The curve at the south-western end of the course was struck to the radius of 1,550 ft., and ample as this may appear, the super-elevation of 17 ft. was found to be necessary, so as to provide for the safety of cars travelling at the contemplated rate of 90 miles an hour. This super-elevation gives the mean inclination of about 1 in 6, the maximum inclination near the outer edge being 1 in $2\frac{1}{4}$.

At the north-eastern end the curve was struck to the radius of 1,000 ft., necessitating the maximum super-elevation of 32 ft., and the maximum inclination at the outer edge of 1 in 2.

Fig. 1 indicates the position of the footpath from Weybridge Station and of roads giving access to Canes Wood, below which the grand stand is being built. Steel bridges will be thrown over the track at these points, and the entrance for motor cars will be through the subway near the junction of the diagonal road with the curve descending from Fox Hill.

A branch railway line for contractors' purposes has already been brought from Weybridge Station to a point outside the curve on Fox Hill, where a passenger station will be provided for the convenience of visitors.

One of the most interesting engineering features of the new track is the concrete-steel bridge, nearly 180 ft. long by 100 ft. wide, crossing the River Wey at the point where the curve merges into the level stretch parallel to the London and South Western Railway. This bridge, built in accordance with the "Hennebique" system of ferro-concrete, is of unusual design, being slightly curved in plan, having a fall at the front of 1 in 90 for three-fifths of its length, and of 1 in 200 for the remainder, and a super-elevation at the back decreasing from 26 ft. down to 15 ft. These measurements necessitate varying curves



FIGS. 3 AND 4.

for the decking of the bridge, the curvature of which increases considerably as the outer edge of the track is approached.

To construct a bridge like this, skewed and curved in various directions, would have proved a costly and difficult task if steel had been selected as the material of construction, and it must be admitted that the proprietors have shown their wisdom in the selection of concrete-steel, a material which can be readily moulded on the site to any form, and possessing solidity and freedom from vibration that is far in advance of steel construction.

Fig. 2 is a plan of the bridge, by which it will be seen that the curve at the outer edge is 178 ft. 4 in. long, and that at the inner edge is 165 ft. long, the latter being struck to the radius of 1,000 ft. for the length of 99 ft., and the remainder to the radius of 2,000 ft.

The foundations comprise six rows of "Hennebique" piles, seven in each row. All these members have the transverse dimensions of 14 in. square, except those in row No. 4, where the size is increased to 16 in. square. Just above ground level the heads of the piles are braced by horizontal walings, and "Hennebique" columns are built up where required to the various levels necessitated by the contour of the decking. The columns are braced longitudinally and transversely as necessary, and are connected at the top by longitudinal arched beams, all 9 in. wide, but ranging from 3 ft. to 4 ft. deep at the haunches according to position.

The columns are connected transversely by beams, with the average dimensions of 6 in. wide by 10 in. deep, and between each row of columns, six continuous secondary beams of the same kind extend from side to side of the bridge. Thus the decking is divided into thirty bays, each of seven panels, and over the supporting columns and beams is laid a continuous slab of concrete-steel with

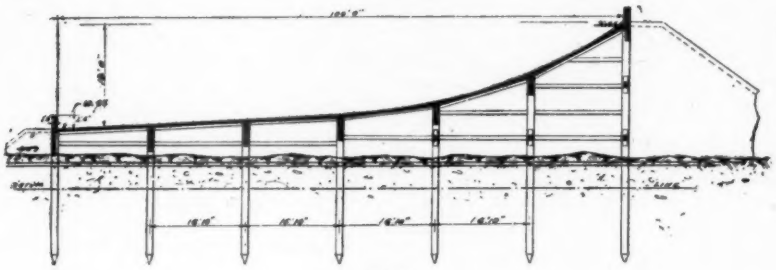


FIG. 5.

the minimum thickness of $4\frac{1}{2}$ in. All this work has been moulded on the site, and besides being monolithic throughout, it is thoroughly tied in every direction by the steel bars with which the concrete is reinforced.

Fig. 3 is an elevation on the line *DD* (Fig. 2), where may be seen the longitudinal arched beams directly connected with the heads of the piles, no columns being necessary along the inner edge of the structure. The arch in each span has the rise of 3 ft. 3 in., and the thickness of the beams at the crown is 1 ft. $8\frac{1}{4}$ in., including the thickness of the deck slab.

As the River Wey is not navigable above the Seven-Arch Viaduct of the

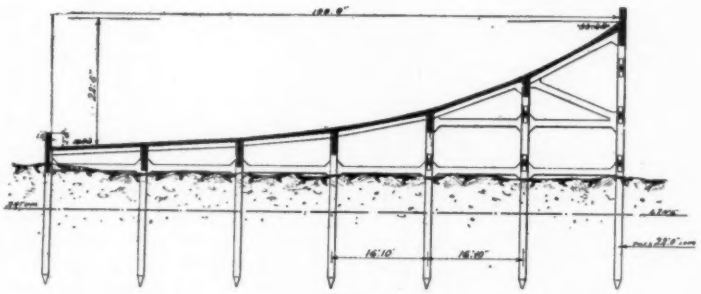


FIG. 6.

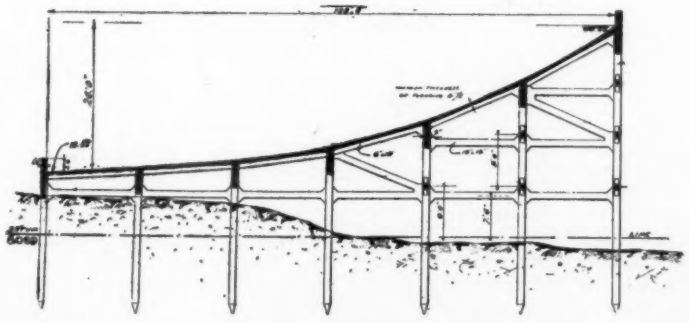


FIG. 7.

London and South Western Railway, the designer was permitted to drive one row of piles along the river bed and thus to preserve the uniform spacing of the supporting piles and columns.

Fig. 4 is an elevation on the line *EE* (Fig. 2), and shows the aspect of the bridge when viewed from the railway side. The river is a little wider here, and two rows of piles are driven into the bed of the waterway. Columns ranging from 18 ft. to 26 ft. high are built in continuation of the piles, which were cut and stripped off to a uniform level, leaving the reinforcing bars to project for incorporation in the concrete of the columns and bracing members.

The columns are braced longitudinally as shown in the drawing, and the reinforcement of the longitudinal members is carried well into the concrete of the columns, where the ends of the bars are securely anchored. All members of the bracing measure 10 in. wide by 14 in. deep, being reinforced for withstanding axial pressures, while at the same time having sufficient metal for resisting transverse strains due to the dead weight of the material and the stresses to which the construction will be subject. With the object of increasing the rigidity of joints between the vertical and horizontal members, all angles are filled in with concrete suitably reinforced by securely anchored diagonal bars.

At each end of the bridge the spaces between the columns are filled in with strongly reinforced vertical slabs, constituting retaining walls for the sand banked up against the structure to form the racing track.

Fig. 5 is a transverse section of the bridge on the line *AA* (Fig. 2), which, as before mentioned, adjoins that part of the track merging into the level straight run parallel with the London and South Western Railway.

This section shows part of the wing wall extending for a distance of about 40 ft. from the back of the bridge, and also part of the wing wall extending for about 10 ft. from the front. Although not more than 6 in. thick, they are so reinforced as to be capable of withstanding exceedingly heavy lateral pressure.

The piles are driven to the depth of about 19 ft. below normal ground level, their projecting heads being connected by the bracing indicated in the section. It will be noticed that the thickness of the deck slab is varied as required by the surface contour and that the arched beams at the inner and outer edges respectively are carried up to the height of 2 ft. 6 in. above the deck level to form curbs, 12 in. thick. The super-elevation on the line *AA* is 19 ft.

Fig. 6 is a transverse section on the line *BB* (Fig. 2) where the super-elevation is increased to 22 ft. 6 in. and more adequate bracing becomes necessary. In other respects the construction is similar to that already described and needs no detailed comment.

Fig. 7 is a transverse section on the line *CC* (Fig. 2) and also applies to the construction of the bridge close to the rows Nos. 4, 5 and 6 of the piles and columns, where the maximum super-elevation of 26 ft. obtains and the columns are stiffened by additional bracing.

The concrete-steel decking is finished with a 1 in. layer of concrete mixed with granite chippings as aggregate.

No official tests of the bridge have been conducted up to the present, but there is no doubt as to its capacity for carrying the specified superload of 1 cwt. per sq. ft., or the rolling motor car load of 2 tons.

The bridge was designed for the proprietors of the track by Mr. L. G. Mouchel, C.E., of Westminster, and the contract was let to the Yorkshire Hennebique Co , Ltd., of Leeds.

Work was commenced in December last year, and completed in the early part of last month in readiness for the formation of the adjoining portions of the embankment.

The Influence of Machinery on the Gun Power of the Modern Warship.

By J. Mc. KECHNIE.

THE influence of machinery on the gun-power of the modern warship is (1) Direct, so far as it relates to the supply of ammunition to the gun, and to the training, elevating, loading, and firing of the gun; and (2) Indirect, so far as it influences the position of the guns on board ship—a matter of increasing importance

In view of the decision to adopt only the largest calibre of gun for the primary armament in our ships, the question of space occupied by the propelling machinery is urgent As this limits the number of guns for the weight allowed for ordnance, it becomes more necessary to make fuller use of the weapons by giving each the greatest possible arc of training, and to ensure the highest percentage of hits within a given time. In other words, if only large calibre guns are to be used, involving considerable weight for the machinery for manipulating them, every gun must be so placed as to enable it to fire on either broadside, and at the same time to give the maximum of bow and stern fire.

To the ordnance officer the space required for the propelling machinery creates difficulties, because the position of the boilers and engines can be modified only to a limited extent. Moreover, the presence of uptakes and funnels seriously interferes with the gun arrangement.

Engineers must therefore recognise the necessity for some modification to meet the new conditions, and this raises the important question as to whether the adoption of internal combustion machinery would not effect an advantage from the point of view of fighting efficiency as to induce naval authorities to encourage the application of this prime mover.

Plans are given showing the application of gas engines to a battleship, and of oil engines to a torpedo-boat destroyer, and with these are corresponding drawings for similar types of ships of exactly the same size, but fitted with steam machinery.* The success which has attended the application of the "Parsons" steam turbine, not only in battleships and cruisers, but especially in torpedo craft, suggests that the fullest advantage will be realised by the development of the same system using gas, or preferably oil, so that steam boilers might be entirely dispensed with; and it would be peculiarly appropriate if this further advance should be initiated by the Hon. C. A. Parsons, C.B., who deserves so much credit for the success of the steam turbine.

Marine Internal Combustion Engines.

Before referring to the designs of the ships with steam and internal combustion engines brief general reference may be made to this type of prime mover. At the Vickers Works at Barrow-in-Furness there have been constructed internal combustion marine engines of a power equivalent to about 40,000 indicated horse power, and for three or four years almost continuous research work has been undertaken. The experiments have led to the adoption of a two-stroke cycle gas engine possessing satisfactory features. This engine may be worked either by producer gas, heavy

* Battleship plans only are reproduced.

oil, or compressed air. It may be made reversible as easily as the steam or compressed air engine. It is possible to use it in conjunction with pressure-gas generators, which deliver their gas direct to the engines, as there is no necessity to pass it through a scrubber, or any other cleansing apparatus. There is thereby ensured the maximum of heat in the engine itself, since none of it is wasted in the process of cleansing. The cycle upon which the engine works renders it possible also to recover the heat of the exhaust gas and to utilise it in the engine. A gas pump is unnecessary, so that one of the chief objections to the two-stroke cycle engine is thereby eliminated.

The compressed-air plant may be located in any part of the ship. From it one main leads direct to the propelling engines and another to the pressure-gas producers. The steam required for keeping down the temperature in the producer and for preventing the formation of clinker is generated in association with the compressed air. The possibility of poisonous gases exuding from the mains has been carefully considered, and the supply pipes, as well as the producers, are jacketed with compressed air, with which the gas escaping from the inner pipe passes to the producer or the engine.

An important feature is that the engine may be worked either by gas or heavy oil, so that coal may be stored in the bunkers and oil in the double bottom. This gives a duplication which is always desirable. The change from gas to oil may be made almost instantaneously. With oil the engine may be started when cold within a few minutes: this would be an important tactical advantage in warships.

The compressor and producer plants are governed automatically, according to the consumption of the propelling engines.

Steam *v.* Oil Engines for Torpedo-boat Destroyers.

Comparing a 30-knot torpedo-boat destroyer fitted with steam machinery, and a vessel of identical dimensions and speed driven by engines using oil having a flash-point of about 200° F., it has been considered preferable to indicate the effect on gun-fire rather than to utilise the economy in weight and space in reducing the size of the vessel or in increasing the speed. Instead of having only one 12-pounder and five 6-pounder guns, the oil-driven vessel is fitted with four quick-firing guns of 4-inch calibre and two 6-pounder quick-firing guns. Both vessels have two torpedo tubes. The quantity of ammunition—the number of rounds per gun—has not been reduced, although the guns carried are of greater calibre. A sufficient quantity of fuel has been allowed to give the oil-driven vessel, at the full speed of 30 knots, a radius of action six and a half times greater than that of the steam-driven destroyer with full coal supply.

The absence of funnels and their fittings enables the guns to have a much wider arc of training. There is usually much smoke and sometimes flames from the funnels of steam-driven destroyers, especially when running at full speed, and the absence of these in oil-driven craft would render them less liable to detection in war. Experience with 6-cylinder oil engines at the Vickers Works shows that there will be less noise than with the reciprocating steam engine.

The difference in weight due to the adoption of the oil engine might, of course, be utilised to reduce dimensions and displacement, the armament being the same.

Steam *v.* Gas-driven Battleships.

Now compare a battleship constructed at the Vickers Works at Barrow-in-Furness (Fig. 1) with a design of a corresponding vessel fitted with the producer gas engines (Fig. 2) already described. The advantages, alike in weight, space, and arrangement, resulting from the use of the gas machinery, have been utilised to improve the gun-power.

The gas machinery is divided into

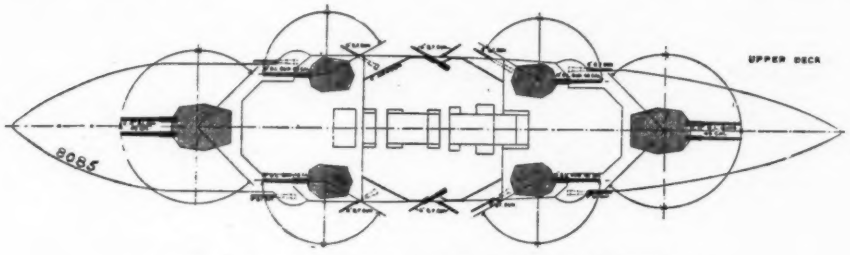


FIG. 1.—FIRST-CLASS BATTLESHIP WITH RECIPROCATING STEAM ENGINES.

Armament: Four 12 in. B. L. guns; four 10 in. B. L. guns; and twelve 6 in. Q. F. guns.

three groups accommodated in six compartments. The ship has four propeller-shafts, each driven by a 10-cylinder vertical gas engine. Two of the sets of engines are placed, each in the four and aft line, in each of the aft compartments. The engines are purely for propelling the ship. The gas producers, of the pressure type, occupy the two centre compartments. In the forward compartments there are four sets of air compressors driven by gas engines.

As of some interest, although not vital to the consideration of the influence of this machinery on the gun power of warships, the approximate weights of steam, gas, and oil machinery of a 16,000 h.p. battleship are given in Table I. These figures would, of course, be subject to alteration when the details of design are made to meet specified conditions.

The steam-driven battleship was fitted with four 12-in., four 10-in., and twelve 6-in. guns—the most effective combination of ordnance in any warship up to 1905. In the new ship it has been found possible, without increasing the length or displacement, to introduce five pairs of 12-in. guns, and to carry eighteen quick-firing guns of 4-in. calibre for repelling torpedo attack.

Here, too, we have each of the main magazines located immediately under the pair of guns which it is intended to serve. Moreover, there is communication between the various ammunition and shell rooms. This has the important advantage of enabling ammunition to be distributed throughout the ship with the greatest facility all on one level. In the event of any turret being put out of action, the ammunition reserved for the guns in it could be used for other weapons, all being transported below the armoured deck.

The benefit derived from the abolition of boiler uptakes and funnels is still more marked. It enables the turrets to be so disposed without increasing the

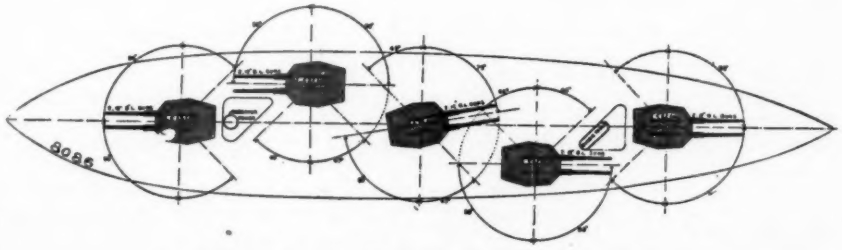


FIG. 2.—FIRST-CLASS BATTLESHIP WITH INTERNAL COMBUSTION MACHINERY.

Armament: Ten 12 in. B. L. guns, and eighteen 4 in. Q. F. guns.

TABLE I.—COMPARISON OF WEIGHTS, &C., OF STEAM, GAS, AND OIL MACHINERY FOR 16,000-H.P. BATTLESHIP.

	Steam Engine.	Gas Engine.	Oil Engine.
I.H.P. available for propelling the ship	16,000	16,000	16,000
Weight of machinery including usual auxiliaries, but not deck machinery	1,585 tons*	1,105 tons†	750 tons‡
I.H.P. per ton of machinery	10·1	14·48	21·33
Area occupied by machinery, engines and boilers, or producers	7,250 sq. ft.	5,850 sq. ft.	4,110 sq. ft.
Area per I.H.P.	·453 sq. ft.	·366 sq. ft.	·257 sq. ft.
Fuel consumption in pounds per I.H.P. per hour—			
At full power	1·6 lbs.	1·0 lbs.	·6 lb.
At about ¼ full power	1·66 lbs.	1·15 lbs.	·75 lb.

* Includes water in boilers.
† Includes water in jackets, and piping, but not coal in producers.
‡ Includes water in jackets and piping.

length of the ship so as to admit of all the ten guns being fired on either broadside. This more fully realises the demand for "all-round fire" for all guns than is the case in any existing ship. It will thus be seen that the internal combustion engine installation allows a much greater range in the gun distribution, and is more adaptable to a reasonable arrangement of magazines than is the case with steam machinery. Moreover, the temperature in the machinery room is lower, and fewer difficulties are involved in the satisfactory heat isolation and ventilation of the adjacent magazines.

In comparing the designs it should be kept in mind that the object is to eliminate any other variant than machinery and gun power, although the actual weight of protective material has been increased. The second design is not put forward as representing an ideal battleship. In producing a design it is, of course, necessary to give attention to other considerations than that of gun power. Thus, part of the saving of weight and of space could be utilised for decreasing the size of the ship while maintaining the same armament and protection as in the steam-driven battleship. Or the weight saved might be used for increasing speed by fitting more powerful machinery, although in this particular case an increased speed would be more economically realised in association with increased length of hull.

The design, however, clearly shows that greater gun power, and a fuller utilisation of such offensive power, is possible with the internal-combustion engine. The machinery is at a lower level in the ship, and is, consequently, better protected. As the power per unit of weight of fuel consumed is greater, the radius of action for the same allowance in displacement would be greater.

The Direct Influence of Machinery on Gun-power.

The direct influence of machinery on gun power has reference to the mechanism required for loading, training, elevating and firing the gun. Rapidity in hitting and wide radius alike in training and elevation, are the principal conditions to be met. The attainment of these call for extreme precision in movement and control, wide ranges in speed, and absolute reliability in all respects of gun mountings. The highest class of material available must be used. In the following Table there is noted the tensile strength of various materials used for gun-mounting machinery and the advance in recent years. Methods of manufacture must be adopted to ensure accuracy of gauge and template work and generally a high quality in the resulting products.

Increase in Tensile Strength for Gun-Mounting Materials.

Plates and Angles for Gun-Slides. From 27–30 tons to 35–40 tons per sq. in.

Steel Forgings (Ordinary). From 28 tons to 30-35 tons per sq. in.

Steel Forgings (High Tensile). From 32 to 35–40 tons per sq. in.

All the smaller forgings on the oscillating portion of the mounting, which were formerly made of steel, having a strength of 28 tons per sq. in. are now made of this high tensile material.

High Strength Bronzes. From 30 to 34 tons per sq. in., and 40 tons per sq. in. for special purposes.

These points, however important, need only be thus hinted at. Of greater interest are the means adopted for insuring precision and wide variation in the rate of speed in training and elevating. The importance of these will be realised when it is remembered that at five miles' range a change in the target of 100 yards means a difference in the position of the muzzle of the gun of only about 0·6 in. in the vertical line, or about forty minutes in the arc of training. The gun, as a rule, is mounted so that it is balanced for vertical movement about the trunnions. The frictional resistance to rotation about the trunnion is now further reduced by carrying the weapon on knife edges or ball-bearings. For horizontal movement the whole system is carried on a ring of rollers in the case of a large gun, and by ball-bearings in the case of lighter guns. As the rolling or pitching of the ship throws the plane of the roller path out of the horizontal, the gun must also be balanced about the vertical axis of rotation. With these conditions realised, the power necessary to operate the gun is reduced to a minimum.

The progress in accuracy and precision of control is indicated by the fact that the mass of 500 tons represented in a modern mounting of two 12-in. calibre guns can be trained at one motion of the valve lever through a distance corresponding to the smallest perceptible movement of the target observed through a telescopic sight.

Hydraulic *v.* Electric Power.

The general arrangement of typical modern gun mountings having been described in the original paper, attention may be directed now to what is perhaps the most important general question affecting the efficiency of the mechanism—namely, the type of prime mover to be adopted. This affects not only efficiency and reliability, but weight. At various times guns have been operated by steam, air, hydraulic, and electric power. The two former are no longer adopted, and as to the others opinion is divided, with the balance perhaps in favour of the hydraulic system. It does not, in the event of the fracture of the supply pipes, involve personal injury or danger; damage is at once visible by leakage, and can be easily repaired; whereas breakage of electric leads is not easily located, and may involve more trouble. Short circuiting, too, may have serious results on the electric generator or associated gear. Any element of uncertainty resulting from such unknown and undiscovered danger might in action be seriously demoralising to the *personnel*. The motion of hydraulic engines and presses is practically silent. They can be worked so slowly that gearing can be dispensed with—a condition not possible with electric driving. In some cases the single-stroke motion of the hydraulic press is more suited to the work than the rotary motion of the electric engine. This is the case, for instance, with the shell-hoist, and possibly also with the elevating gear and gun-loading mechanism.

For controlling the gun during recoil, and for running it out after recoil, this single-stroke motion is superior. All guns, from the newest 12-in. breech-loader to the quick-firing six-pounder gun, have their recoil controlled by hydraulic power, generally in the form of independent presses, which are not

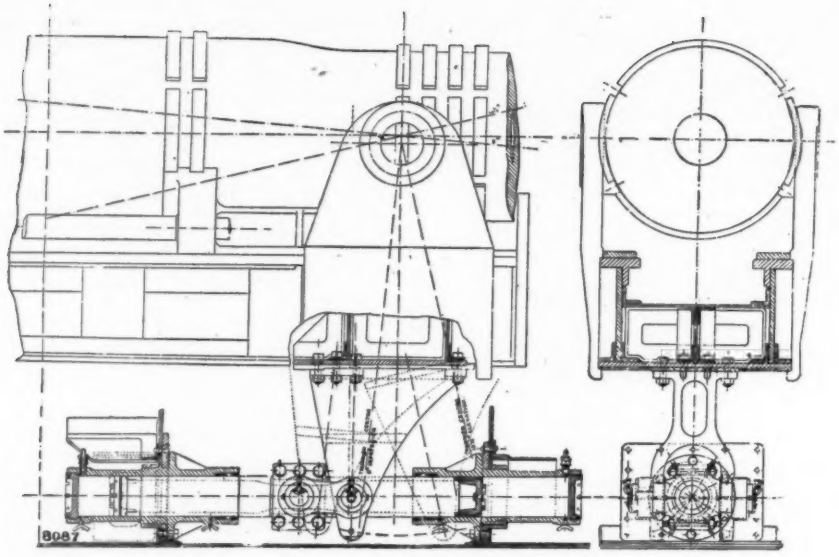
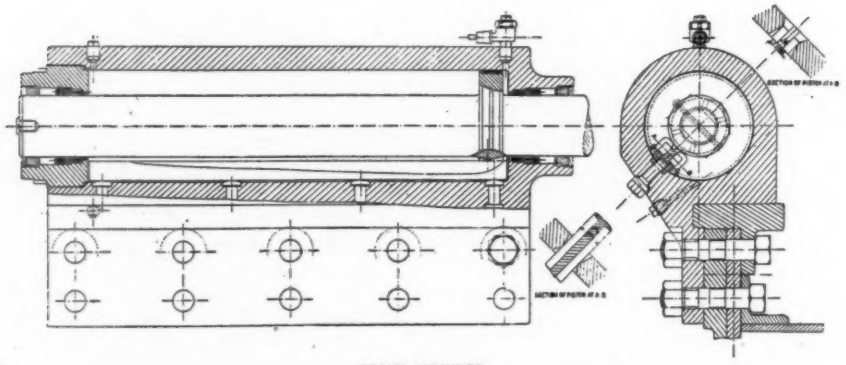


FIG. 3.—HYDRAULIC ELEVATING GEAR.



RECOIL CYLINDER.

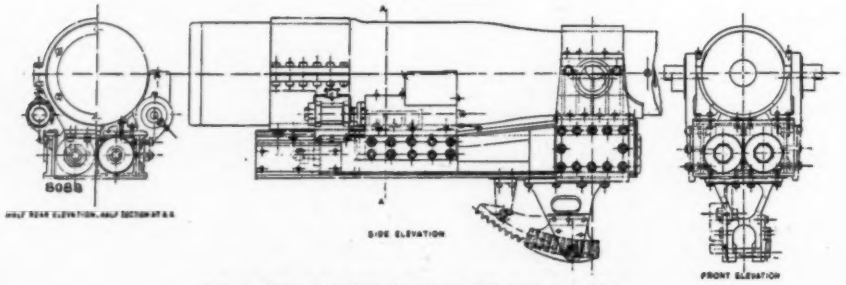


FIG. 4.—HYDRAULIC GUN MACHINERY FOR 10 IN. B. L. GUNS.
Arrangement of cradle, recoil cylinder, run out springs, and elevating arc.

connected to the pressure system of the ship. For running out the gun to the firing position, the hydraulic system is superior, but other methods are available. Electricity, however, is quite unsuitable, and with electrically operated gun-mountings in some foreign ships a supplementary hydraulic system is occasionally fitted. More frequently springs are used with guns of medium calibres, and occasionally even with guns of 12-in. calibre having a moving weight up to 65 tons. Compressed air is also adopted occasionally. Both these alternative methods are satisfactory, but they each involve additional weight, especially when springs are used. Moreover, springs are not so reliable as the hydraulic press, as they may fracture suddenly. Several columns of springs may be fitted, in which case the breakage of a spring in one column would not affect the run-out of the gun at small angles of elevation, and possibly at all angles, if there were a sufficient reserve of spring power; but the objection exists, and detracts from the reliability of an essential part of the mechanism. A 12-in. gun recoils a distance of nearly 3 ft., and attains a maximum velocity of over 20 ft. per second; it has to be run back to its firing position through this 3 ft. in about four seconds, and must be slowed down gently and quickly in the last 3 ins. or 4 ins. of its travel. Thus considerable stress is involved.

There are, however, several parts of the mechanism to which the electric system is adaptable, perhaps even preferable; and thus there is in many modern warships a combination of hydraulic and electric power. The latter is more freely applied for special parts, because, current being available, no special generating plant is required. To obtain precision of control, however, it is necessary when using electricity to introduce motor generators for supplying current to the operating motors, so as to be able to vary the voltage at the operating-motor terminals. This involves additional weight and complicated electric leads.

Elevating Gear and Recoil Mechanism.

Fig. 3 illustrates the latest method of elevating the gun by hydraulic power. The slide is provided with a bracket projecting downwards, and engaging with hydraulic presses. Pressure may be admitted at will to either press, causing a corresponding movement of the gun in elevation. The presses are brought into action by the gun-layer, and are automatically controlled by a device which makes it impossible for either gun, when at extreme angles of depression, to fire into the deck of the vessel on which it is mounted. It is possible to elevate the gun by hand, and the change over from one system to the other is usually effected simply and readily by utilising the hydraulic pressure to place the hand gear out of action, generally by releasing a friction clutch.

In the most modern arrangement, the recoil cylinders are separated from the run-in and out cylinders, the recoil is controlled by two recoil presses attached to the side, while the run-in and out presses are connected by a double ram.

The recoil cylinders are placed to the rear of the gun-slide and attached thereto, one on each side below the axis of the gun. They are provided with pistons and rods, with one end passing through a suitable gland towards the muzzle of the gun, and secured to the rear of the gun-cradle. The other end, of the same size, passes through the rear gland only sufficiently to protrude therefrom. The pistons formed solid with the rods, and approximately midway between them, are just clear of the front end of the cylinders when the gun is in firing position.

These two cylinders, with their rods, form the recoil apparatus, and absorb the great bulk of the recoil energy when the gun is fired. When the gun recoils the piston-rod, being attached to the carriage, moves with it, one rod passing into the cylinder while the other passes out. The quantity of liquid in the cylinder is constant, irrespective of the

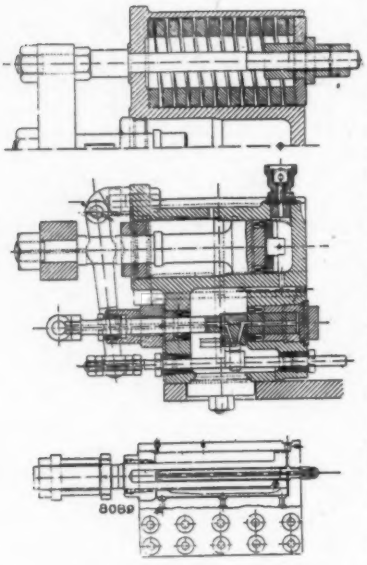


FIG. 5.—HYDRAULIC PRESSURE GOVERNOR AND DETAIL OF RECOIL CYLINDER.

position of the piston in the cylinder; but as the piston moves to the rear, the liquid passes from one side to the other through a control orifice in the piston, which is illustrated in Fig. 4. The orifice is rectangular, with highly polished and rounded edges, and is arranged to fit on a key securely attached in the cylinder; but the key is formed so that, although it fits sideways and upwards in the orifices, it has two grooves at each side, of varying depth but constant width; it is through these grooves that the liquid is compelled to pass from one side of the piston to the other when the gun recoils with a constant velocity of flow, irrespective of the varying velocity of recoil of the gun. It thus depends on the varying depth of the grooves whether the gun-slide and all its appurtenances shall be subjected to injurious or normal stresses.

Hydraulic Pumping Engines.

A brief reference may be made to the hydraulic generating plant employed on warships. This always consists of at least two independent pumping engines, so that one or both can be employed to maintain a practically uniform pressure throughout the ship. The piping is usually arranged on the ring system—*i.e.*, a complete ring of piping running along each longitudinal ammunition passage and joined transversely in the cross lobby, forward and aft, of the machinery and boiler-room spaces. The engines are generally placed one forward and one aft, and as near to the barbettes as possible. Owing to the limited space between decks it is arranged with its cylinders and pump-barrels horizontal. Heavy fly-wheels are not permissible, and the steam cut-off is generally late. The engine, in the absence of an accumulator, has to maintain uniform pressure, and a special type of governor has been devised which, in this instance, maintains all speeds between a minimum of 3 revolutions per minute and a maximum of 110 revolutions, while the variation in pressure is only about 100 lb. per sq. in. The pressure, normally ,is 1,000 lb. per sq. in.

The special type of governor is shown in some detail in Fig. 5. It is necessary also, in conjunction with this, to employ an ordinary centrifugal speed-governor, in order to prevent racing in the event of the pressure falling abnormally low, owing to the bursting of one of the pipes of the hydraulic system, or to some other cause. A speed-governor of this type, arranged in a simple manner, is provided with an improved safety device, which, if the governor should once close the steam-valve, will prevent its being opened again until the cause of the racing has been removed. The speed-governor is so arranged in combination with the hydraulic pressure-governor that the motion of these two governors, though produced by different causes, operates the steam-valve always in the same direction.

The hydraulic supply for rotating the turn-tables is usually in duplicate, and is generally arranged in the space below the revolving structure, where walking pipes, consisting of two movable arms

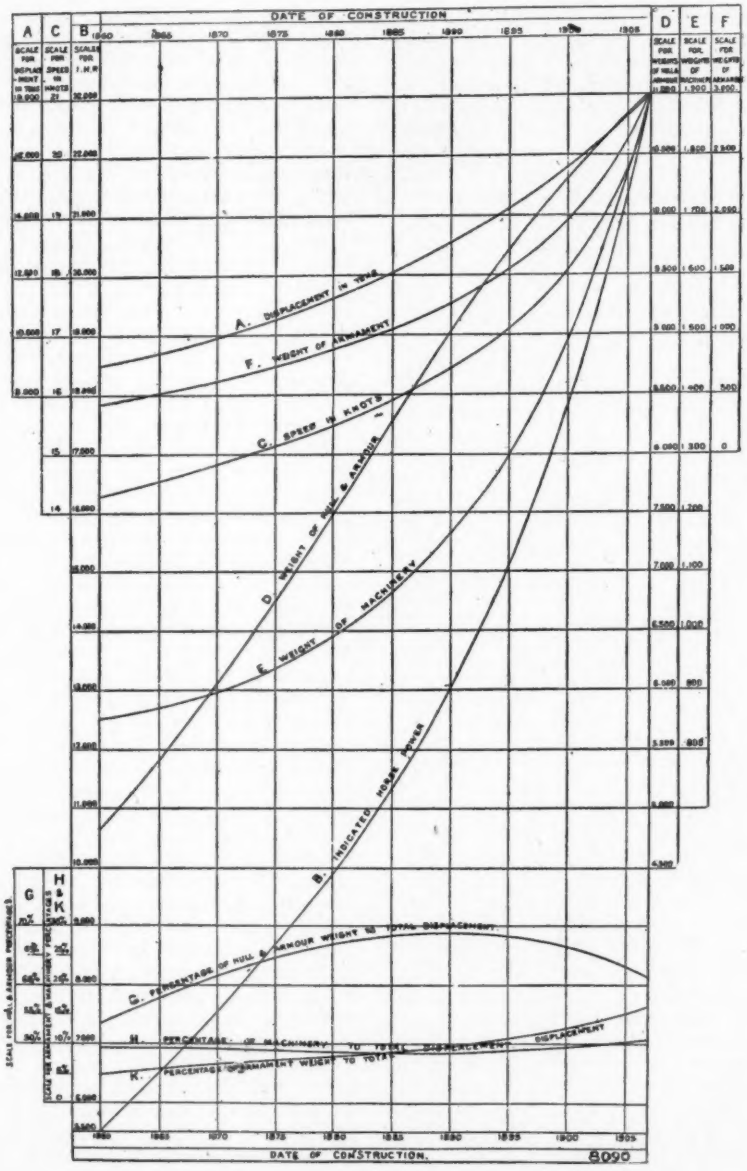


FIG. 6.—DIAGRAM SHOWING THE PROGRESS OF DEVELOPMENT OF THE BATTLESHIP.

and two fixed end boxes, convey the water from the non-revolving part of the structure to the revolving part, one end box being attached to the latter and the other to the former. Guides are provided to enable the swinging pipes to keep their correct positions when passing over the dead centre.

Retrospective and Prospective.

This review of the present state of success in the machinery of a warship may prove the basis for future advance; but it will be recognised that in few departments of applied science is greater experience necessary, not only from a mechanical, but also from the fighting point of view, than in the design and manufacture or ordnance machinery. The progress of the past and our present position in this branch of industry amongst the great manufacturing nations justifies the belief that in the future we shall maintain our supremacy. An investigation of the development of the battleship from the ordnance standpoint has enabled a diagram to be prepared showing this progress (Fig. 6). The curve marked

A shows the actual growth of displacement in tons;
B the advance in horse-power of propelling machinery;
C the progress in speed;
D the weight of hull and armour;
E the weight of machinery, and
F the weight of armament, including all guns, with such of their protecting armour as is not attached to the ship.

These curves have been drawn to show the mean results over a period of 47 years; in other words, they strike a mean path amongst "spots" representing the particulars of the most important battleships of successive years. This has been accepted as a simpler method of indicating advance than by the plotting of a curve with the irregularities due to the linking up of the spots.

It will be seen that the displacement tonnage has doubled in the forty-seven years; that the indicated horse-power has quadrupled, while the speed has advanced 50 per cent. This suggests higher propulsive efficiency, alike as regards machinery and form of hull.

In measuring the relation of the weight of hull, armour, armament, and machinery to the total displacement tonnage of the ship, the only comparative basis seems that of percentage, which is often more or less misleading. This is especially the case when this mode of analysis is applied in comparing particular designs of ships, because the amount and distribution of armament, the arrangement of protective material, the speed required, and the coal carried on the normal draught may lead to inaccurate assumptions. In this case, however, we are concerned only with the general trend. There are produced on the diagram three curves, *G*, *H*, and *K*, to show the percentage of (*G*) hull and armour, (*H*) machinery, and (*K*) armament respectively to the normal displacement tonnage of successive ships since 1860. These curves differ from the others, being plotted to identical scale.

In the older types of ironclads, from 1860-1870, the weight of hull and armour was smaller in proportion to the displacement than in the ships constructed between 1875-1890, but in the more recent vessels the proportion of hull and armour has been again reduced. This latter reduction is probably accounted for by the greater resistance to penetration of modern armour per unit of weight, and to the adoption in the hull generally of material stronger per unit of weight.

Of immediate interest is the fairly constant percentage of weight of propelling machinery to the total displacement tonnage, notwithstanding that the total indicated horse-power per ton of displacement has greatly advanced. Thus, at the beginning of the ironclad era the horse-power of the machinery of the *Warrior's* time was equal to about 0·60 i.h.-p. per ton displacement, whereas the weight of machinery alone — *i.e.*, excluding coal — was about 9·5 per cent. of the displacement tonnage. In the time of the *Royal Sovereign* class, which marked a new era in warship design, the

power has increased to about 0·95, and the weight of machinery alone was 9 per cent. In the *King Edward VII.* class, which again marked a new departure, the power was about 1·14 i.h.-p. per ton, while the proportion of weight was about 10 per cent. of the total.

It will thus be seen that the marine engineer, notwithstanding the greater demands made upon him for higher power, has assisted the naval architect to keep the displacement tonnage of the ships as low as possible. In other words, the power of the propelling machinery per unit of weight has increased from about 6·3 i.h.-p. in the *Warrior* to about 10·75 i.h.-p. in the *King Edward VII.* class, and about 12·5 i.h.-p. at the present date.

As regards the percentage of weight of armament to the total displacement tonnage, shown in curve *K*, there has been a steady increase; but at the same time there has been a much greater advance in the gun-power of our ships, so that here progress has been most marked.

Forty-seven years ago, the broadside-fire of the newest battleship was made up by four guns of 8-in. calibre, and fourteen of 7-in. calibre, but the former were weapons of only 9 tons, and the latter of 6½ tons. In the *Devastation*, of 1871, the broadside-fire was four 12-in. guns. In the *Royal Sovereign*, of twenty years later, it was increased to four guns of 13½-in. calibre, with five 6-in. guns, but in the interval a great advance had been made in gun-construction, so that the power of each weapon had greatly increased. In the *King Edward VII.* class we have as broadside-fire four 12-in. guns, two 9·2-in. guns, and five 6-in. guns, while in the *Dreadnought* the broadside-fire is eight guns of 12-in. calibre.

The bore of the gun, however, affords little indication of its power. The 12-in. gun of to-day has double the muzzle energy of that of 1885. Fifteen years ago the muzzle energy developed by two guns was equal to 373 foot-tons per ton of gun-mounting, excluding the gun and shield; to-day this energy is 533 foot-tons.

Thus, while doubling the striking power of each gun, the ordnance engineer has not greatly increased the weight, and has simplified and improved each unit in the mechanism, to ensure more accurate control of the gun, a greater rate of fire, and fuller reliability. Beyond this there is the still more important fact that while encouraging improvement in material, the distinguished officers responsible for our naval policy have brought about a great advance in the percentage of hits within a given time by perfecting the system of fire-control, and have thus added enormously to the influence of modern machinery upon the fighting efficiency of warships.

[*Proceedings of the Institution of Naval Architects: Abstract.*]

Pumping Coal.

Mining coal by means of a pump and dredge from the bed of a river seems at first thought an absurdity; but in the bed of the Susquehanna River are large deposits of coal washed from the coal piles and culm banks along the upper river. Dredging and pumping of this coal is regularly carried on, no less than 25,000 tons being taken from the river each year.

This coal is thoroughly washed and has been preserved from the action of the air, so that its heat value is high. The coal is found, for the most part, behind sand bars and back of the piers of bridges and in other places where eddies are formed. The pumping is accomplished by means of an ordinary pan pump driven by a portable engine on a flat barge, the discharge being upon a screen of ¾-in. square mesh, through which water and sand pass to the river and from which the coal, after being cleaned of stocks and stones, is discharged into a flat boat.

One company has a regular pumping outfit consisting of six flat boats of 12 tons each, two-decked working boats and a stern-wheel shallow draft steamer for towing. The company pumps about 9,500 tons of coal a year. The average cost of coal delivered to the boiler room is 87 cents a ton. In burning, it is mixed with bituminous in the proportion of one bituminous to ten anthracite in order to give a greater boiler capacity.

RAILWAY ENGINEERING NOTES.

Rail-Motor Trains on the Great Northern Railway of Ireland.

The Great Northern Railway of Ireland has recently introduced two types of motor trains, one of which works between Dublin and Howth, and the other between Belfast and Lisburn. The first mentioned is the more interesting of the two, inasmuch as it differs from any type of motor train at present in use on other lines.

It is illustrated in Fig. 1, and, as will be seen, is composed of two cars and one tank engine, a car being coupled to either end of the engine so as to form one unit, thus enabling the train to be operated from either end. The outer ends of the train have driver's compartments, which are fitted with all the necessary equipments for driving the train in either direction; but the train cannot be operated from either end at the same time.

The steam regulator on the engine is operated from the driver's compartments by a system of shafts and levers, and must be coupled to the regulator on the engine by the driver for which end of the train he is going to drive from.

Chadburn's Patent Mechanical Telegraph with electric reply is also provided, which indicates to the engine footplate the direction the driver wants the train to move and position of reversing lever. A vacuum brake valve, hand brake, and whistle operating gear are also fitted.

The cars are 53 ft. long by 9 ft. 6 ins. outside. One is divided into driver's compartment, first-class compartment, vestibule, third-class compartment, vestibule, first-class compartment and luggage compartment, and will seat twenty-one first-class and thirty-eight third-class passengers. The other car is similarly divided, with the exception that the first-class compartment next the luggage compartment is a third-class, and will seat nine first-class and fifty-six third-class passengers. The cars are fitted with Stone's electric lighting, and Gold's storage steam heating.

The first-class compartments are trimmed with Moquette, the sides and ends panelled out with light grey walnut, with dark walnut facias; over the seats are photographs and bevelled edge mirrors in carved walnut frames. The roof is panelled out in Lincrusta Walton, coloured in white and gold.

The third-class compartments are trimmed in crimson seig, the sides and ends are finished with V-jointed matchwood and mahogany facias.

The windows in all compartments are fitted with Laycock's balanced blinds; the compartment doors are on the twin sliding principle, and the vestibule door is hinged to open inwards, having inside handles.

The trailer cars were made in the company's works at Dundalk, and the engines are of the type built at the company's works for service on short branch lines, and some of them have been rebuilt and modified so as to work between two cars, as shown in the illustration.

The engine is a four-wheeled coupled bogie tank, with cylinders 15 ins. diameter, 18-ins. stroke, coupled wheels 4 ft. 7 ins. diameter, bogie wheels 2 ft. 7 ins. diameter; coupled wheels 6 ft. 6 ins. centres, and bogie wheels 5 ft. 3 ins. centres, with a total wheel base of

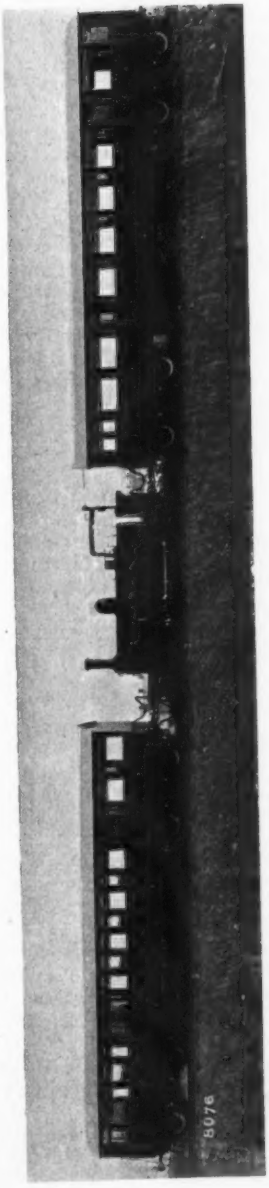


FIG. 1.

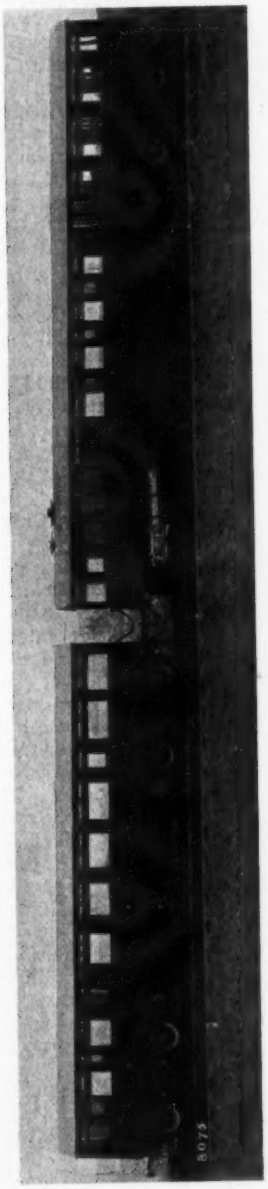


FIG. 2.

STEAM MOTOR TRAINS, GREAT NORTHERN RAILWAY OF IRELAND.

17 ft. 7½ ins. The boiler is 8 ft. 10¼ ins. long, 3 ft. 7 ins. minimum internal diameter; fire-box casing is 3 ft. 10 ins. long by 4 ft. 1 in. wide; the heating surface of the fire-box is 59 sq. ft.; tubes 535 sq. ft., and grate area 11¼ sq. ft. In the cab is placed Chadburn's mechanical telegraph indicator, operated from either of the driver's compartments at the end of the train. The total weight of engine in working order is 31½ tons; the tanks have a capacity of 550 gallons and the coal bunker 1½ tons.

This train will always be driven from one of the driver's compartments at the end of the train; should the traffic not demand two cars, however, one of them can be easily detached, and the train would then be driven from the footplate of the engine in one direction.

The time allowed for running the 8¼ miles, including four intermediate stops between Dublin and Howth is 22 minutes.

In the second type of steam rail motor (Fig. 2), operating between Lisburn and Belfast, the cars are coupled together to form one unit which can be operated from either end, and is 120 ft. 6 ins. long over the buffers.

The motor car is 65 ft. 6 ins. long over buffers, and is carried at one end on the engine bogie, which also carries the boiler; the other end is carried on a four-wheeled carriage bogie.

The trailer car, which is 55 ft. over buffers, is carried on four-wheeled bogies at either end, and is coupled to the engine end of the motor cars.

The outer ends of the train have driver's compartments, which are fitted with all the necessary requirements for driving the train in either direction; but the train cannot be operated from either end at the same time. The steam regulator in the engine compartment is operated from the driver's compartment by a system of shafts and levers, and must be coupled to the steam valve in the engine compartment by the driver for which end of the train he is going to drive from. They are also provided with Chadburn's mechanical telegraph and electric reply, which indicates to the engine compartments.

The motor car body is 61 ft. 6 ins. long by 9 ft. 6 ins. wide outside, and is divided into five compartments, namely, motor, luggage, third-class, vestibule, first-class and driver's compartment, with central passage, so that the driver may pass from the motor compartment to the driver's compartment.

The motor compartment is 13 ft. 9 ins. long, and contains the boiler with all necessary fittings for driving and firing, and provided with a coal bunker for carrying 16 cwt. of coal, and pipes for filling the water tanks, which have a capacity of 550 gallons, and is secured to the underframe of the car.

The luggage compartment is 4 ft. 6 ins. long with double doors each side.

The third-class compartment is 20 ft. long, and is divided for smokers and non-smokers by a glass partition, and will seat thirty-nine passengers. The first-class compartment is 15 ft. long, and is divided for smokers and non-smokers by a glass partition, and will seat twenty passengers.

The boiler is of the vertical multi-tubular type, with a working pressure of 175 lbs. per sq. in., and a heating surface of 653 sq. ft., and a grate area of 11½ sq. ft.

The engine is of the four-wheeled coupled type, with two cylinders 12 ins. diameter by 16-in. stroke placed outside the frames in front of the wheels; the connecting rod driving the trailer pair of wheels, and is fitted with the "Walschaert" type of valve gear. The coupled wheels are 3 ft. 9 ins. diameter, placed 8 ft. apart.

The trailer car body is 51 ft. long by 9 ft. 6 ins. wide outside, and is divided into three third-class compartments with two vestibules and a driver's compartment at one end. This car will seat seventy-eight passengers.

The train is fitted throughout with Stone's electric light and Gold's storage steam heating.

The trailer cars were made in the company's works at Dundalk, but in the case of the motor cars, the engine

portion was made by Manning, Wardle & Co., Leeds, and the car portion by the Brush Electrical Engineering Co., Loughborough.

The time allowed for running the $7\frac{1}{2}$ miles, including five intermediate stops between Belfast and Lisburn is 25 minutes.

A Heavy American Tank-Engine.

A fine example of an American heavy tank engine has recently been completed by the American Locomotive Company for service between the mines and smelting works of a large copper company. As will be seen from the illustration, it is of the 2-8-2 type, and is so constructed that the height of the centre of the boiler from rail level is greater than usual with this diameter of boiler.

This high pitching of the boiler, however, is obtained without raising the centre of gravity of the whole engine, as the tanks have been placed as low as possible, an arrangement which facilitates inspection and repairs, since an ample space is left between the boiler and motion.

To afford a capacious water-holding space, the inner side of the tank follows the curvature of the boiler, an arrangement which involved the reach rod being passed through the tank. The rod is enclosed in a conduit which has flanged connections with the rear and front ends of the tank, and with a casting bolted to the bottom of the tank. This casting is open at the bottom, through which the arm of the reversing shaft passes, the opening being sufficiently large to permit the free operation of the arm.

Another feature consists in the method adopted of equalising the front truck and the two forward pairs of driving wheels, and by which the lateral movement of the truck—which is of the radial inside bearing type—is provided for. The forward equaliser beam rests on a cross-spring, the ends of which are capable of a vertical movement with respect to the frame. These bearings are guided by hollow rectangular castings, which enclose the bearings and are attached to the frame. The bearings rest on the top of a continuous axle box, plates being interposed between the bearing and the box to act as wearing surfaces.

The cylinders are simple, being 19 × 26 ins., and the driving wheels are 48 ins. diameter. The boiler is 5 ft. $6\frac{1}{8}$ ins. diameter at the front end and the working pressure is 200 lbs. per sq. in. The heating surface is in all 2,643·6 sq. ft. made up of 166 in the fire box and

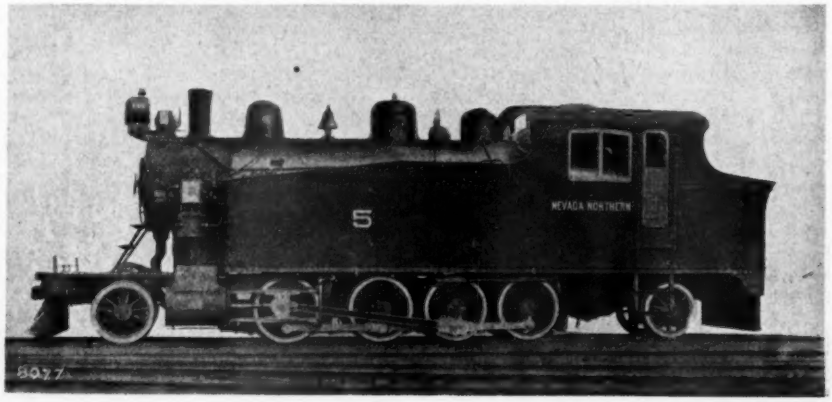


FIG. 3.—SUBURBAN TANK ENGINE FOR THE NEVADA RAILWAY.

2,477·6 in the tubes, the latter numbering 304 each of 2 in. diameter.

The total weight of the engine is 225,000 lbs. and with a weight on the drivers of 172,000 lbs. and a calculated tractive power of 33,240 lbs., the ratio of tractive power to adhesive weight is as 1 to 5·1.

Another point worthy of mention is that the front end of the coal box is sloped downwards towards the rear, giving an extra 2 ft. 6 ins. space, which greatly facilitates the operation of firing up.

The Thermo-Dynamic Efficiency of Locomotives.

Reference was made in our notes of last month to an article that appeared in a recent issue of the *Times Engineering Supplement*, in the course of which the author referred to a system whereby a greatly increased thermo-dynamic efficiency could be obtained in connection with locomotive working.

This system, known as the "Field-Morris," consists of forcing into the steam, under suitable pressure, a definite and exact proportion of air, and superheating the mixture before it is admitted to the cylinders, whereby more work is obtained than with ordinary or superheated steam.

The efficiency of the combined mixture, under favourable conditions, is stated to be practically doubled, so that under ordinary working and running conditions an increased practical efficiency of from 20 to 60 per cent. per unit of steam, corresponding to the pressure and superheated temperature of the steam and air employed, might be expected.

If this be the case, it is indeed a remarkable and interesting discovery, but in the absence of full details of the tests made these claims require to be received with the utmost caution.

The writer, in seeking a cause of the phenomenon, considers the possibility of the particles of air and steam enveloping each other, or of combining in an intimate molecular or atomic condition. This, he is of opinion, would tend to preserve, and perhaps increase, the specific heat of one or other or both air and steam so as to prevent initial condensation from taking place as the steam passes from the superheaters to the cylinders.

Superheating Trials on the Paris and Orleans Railway.

A series of trials recently carried out on the Paris and Orleans Railway of France would appear to point to the superior economy in fuel consumption of their compound locomotives over simple engines fitted with superheaters to the extent of at least 8 per cent. Quite recently, five simple engines of the 4-6-0 type, built at the Baldwin Works in 1900, were fitted with "Schmidt" superheaters. The firebox and smokebox tube plates were replaced by new ones, and ninety-six of the 2-in. tubes were replaced by twenty-one tubes 5 ins. diameter, in which were placed the superheater tubes; these tubes connect with a header in the smokebox. A Schäffer and Budenberg pyrometer was attached to indicate the temperature of the steam. In order to test the results, observations were made on the regular runs from Paris to Orleans and return with fast passenger and mail trains, making an average speed of forty miles per hour. These trips were made with the converted engines and with others of the original type, the railway company's dynamometer car being attached to the tender in each case. The fuel comprised a mixture of 60 per cent. of English coal and 40 per cent. of coal briquettes. The temperature of the steam ranged usually from 250° to 270° at starting and from 300° to 350° when running; it even attained 370°, but this caused leakage of steam and the lubricating oil smoked, and it was necessary to reduce it to 350°. To ensure the proper operation of the superheater it was found necessary to clean its tubes at each end of the run, using special cleaning rods. The leading particulars of the engine are as

follows, the figures in parentheses relating to the engines with superheaters:

Driving wheels, 5·61 ft.
Cylinders, 19·3 × 26·4 ins.
Heating surface, firebox, 129·12 sq. ft.
„ „ tubes (1,338·54 sq. ft.), 1,685·87 sq. ft.
„ „ total (1,467·66 sq. ft.), 1,814·99 sq. ft.
Superheating surface (295·90 sq. ft.).
Grate area, 26·47 sq. ft.

According to the *Engineering News*, a summary of the results of the tests shows that the simple engines fitted with superheaters developed an average economy of 20·8 per cent. in water and 16·6 per cent. in fuel, as compared with similar engines without superheaters. As the boilers of these engines had shallow fireboxes and a forced draft, the use of the large tubes diminished the draft and improved the working of the boiler. It was not thought that an equally high saving in fuel would be maintained with other engines having deeper fireboxes. A comparison of the results with those of the latest compound engines on this road indicate about the same consumption of water on both engines, but, as stated above, an economy of fuel consumption in favour of the compounds.

Apparatus for Determining the Wear of Rails.

Owing to the fact that the Metropolitan Railway of Paris follows the course of the streets, the line abounds in sharp curves, many of which have a radius of 50 metres, and some even of 30 metres. In spite of the introduction of new bogie stock the rail wear is naturally very severe, and necessitates frequent and careful inspection. To enable exact measurements of wear to be ascertainable even by unpractised men, a simple apparatus has been designed by the engineers of the company and is illustrated in the annexed illustration, Fig. 4.

The portion of the apparatus *A* which

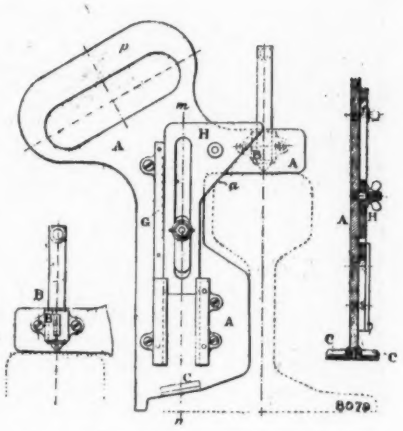


FIG. 4.—APPARATUS FOR DETERMINING THE WEAR OF RAILS.

is shaped to fit the foot, the inner and wearing surfaces of the head of the rail is mounted on the flanges *C*, and terminates in a handle *P*, by which latter it is applied to the rail in the manner shown in the illustration.

The wear in a vertical direction is measured by the graduated cursor *B*, mounted at the end of the templet *A*, and sliding in the bracket B^1. Lateral wear is given by the difference between the vertical wear and the figure indicated by the cursor on the graduated portion at *G*.

As the stop *a* of the cursor *H* is inclined 45 deg. to the vertical, the distance through which *H* must descend commencing from zero (corresponding to the templet of a new rail) to bring *a* in contact with the more or less worn head, represents the sum of the vertical and lateral distances worn.

The difference which exists normally, in the case of a new rail, between the point of tangency *a* and the tangent horizontal to the running surface is, of course, taken into account, it being a constant which can be deduced for all readings by regulating the position of the zero on scale *G*. Greater precision in measurement is obtained by the use of verniers on each cursor.

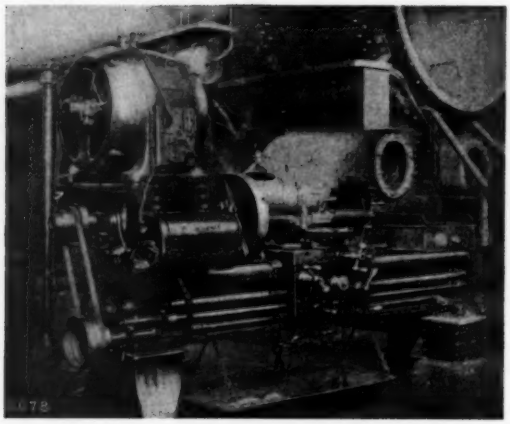


FIG. 5.—18 INCH LATHE IN ERECTING SHOP.

Portable Machine Tools in the Erecting Shop.

Some interesting applications of portable machine tools have been made in the erecting shop of a railway in the United States, one of which is shown in the accompanying illustration (Fig. 5), for which we are indebted to the *American Engineer and Railroad Journal.*

The tool therein depicted is an 18-in. lathe, and is used principally for turning cylinder, saddle and frame bolts. It is electrically driven, current for the motor being supplied through a flexible cable from stands or posts between the pits, one of which is to be seen to the left of the lathe. The posts are fitted with sockets to take plugs for incandescent lamp extensions, and have also 25 ampere capacity plug receptacles from which the extension wires are carried to various points to operate the 5 h.p. motors. The lathe is transported to different points on the erecting floor by means of a travelling crane. In lifting the lathe a hook is passed through the eye-bolt at the top of the motor and a chain is passed round the bed at the tail-stock end. The cast-iron pan, suspended underneath the bed by chains, catches the greater part of the cuttings so as not to litter the floor. The electric light attached to the standard on the lathe carriage receives its current from the lamp-post. The lathe can quickly and easily be placed near an engine when the bolts are ready for fitting and the operator does not have to waste his time running backwards and forwards between the machine and erecting shop.

Locomotive Parts in Cast Steel.

In 1895 the Northern of France commenced a series of trials with cast steel locomotive parts, which hitherto had been, and are now, usually constructed of forged iron or steel. By the courtesy of M. du Bousquet we are able to give the following details of the experiments and to illustrate a locomotive to which the various parts, such as connecting and coupling rods, valve gear, &c., have been applied.

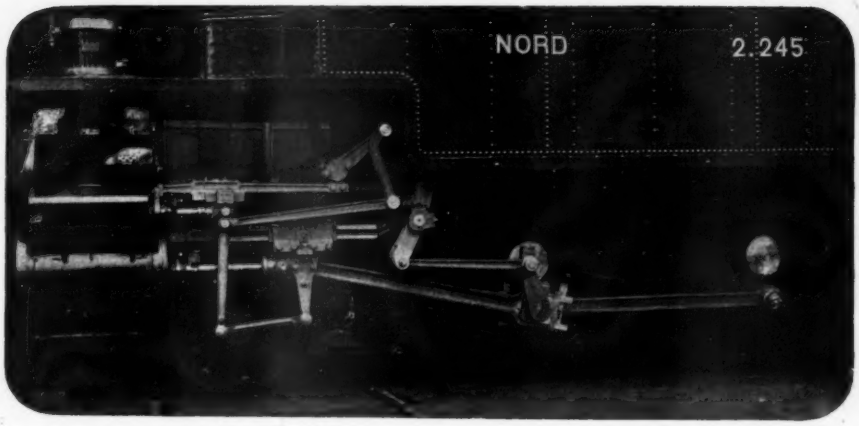
The first experiment was made with a four-coupled goods engine with driving wheels 1·3 m. diameter, to which the following parts, in cast steel, were applied: piston heads, driving boxes, slide bars and supports, and valve gear parts.

After making a mileage of over 500,000 km. all the parts and surfaces were found to be in good condition, the wear of the piston heads and slide bars being only 1·5 mm.

In 1902 another locomotive of the same series was fitted with two coupling rods of the same material. Three rods were ordered, the third being reserved for bending, impact and tension tests. The rod was found capable of supporting, without breaking, the impact of seventeen blows of a tup of 500 kgs., the distances of the drop being as under:—

First 12 blows	0·5 m.
13th blow	0·750 m.
14th, 15th and 16th blows	1·000 m.
17th blow	2·000 m.

At the 18th blow, the tup falling



LOCOMOTIVE WITH CAST STEEL MAIN RODS, VALVE MECHANISM, &C., NORTHERN OF FRANCE RAILWAY.

a distance of 3 m., one of the arms of the fork of the piston big end broke. The trials were continued with a steam hammer of 300 kgs., the rod being bent until the two extremities were within 20 cm. from each other, when the rod broke. The tension tests, which were carried out with test pieces cut from the body of the rod, adjacent to the heads, gave the following results :—

Mean resistance in kgs. per mm. : $R = 51{\cdot}4$.

Mean extension per 100 mm. : $A = 25$ per cent.

The requirements of the specification were: $R = 45$—50 kgs., and A 20 to 15 per cent.

Afterwards two planed bars, of 30 mm. square section were submitted to breaking tests. The supports were 160 mm. apart, the bars being submitted to blows from a tup of 25 kgs. falling from distances increasing by 0·05 m. to 0·7 m. Rupture occurred in the case of the first bar when the distance reached ·2 m., this height being exceeded in the case of the second bar. After making a mileage of 161,000 km., the rods put in service showed no sign of a flaw.

In 1904 a four-coupled suburban passenger locomotive was fitted with all the motion and break parts in cast steel. The characteristics of this steel were as follows :—

(*a*) Pieces which should resist the wear caused by friction, resistance in kgs. per mm. = 60 k. minimum.; elongation measured on 100 mm. as large as possible.

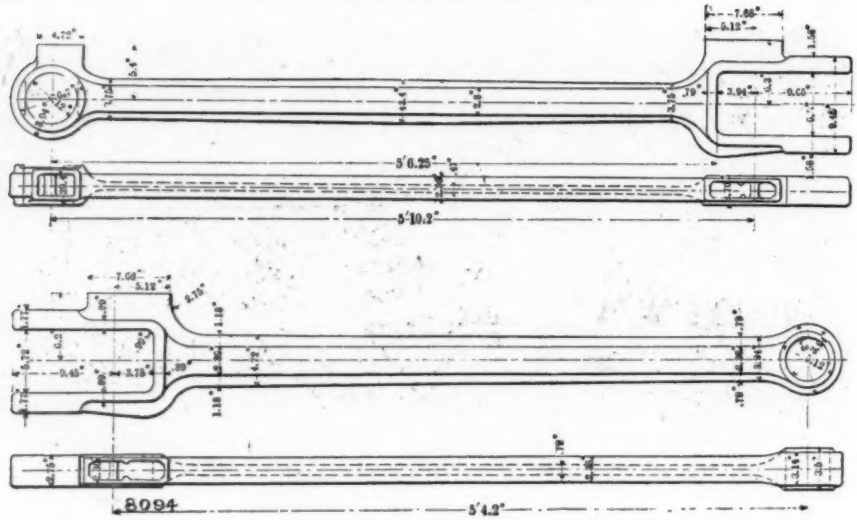
(*b*) For the other pieces, resistance in kgs. per mm. = 45 minimum ; elongation measured on 100 mm. = 15 minimum.

After a mileage of 150,000 km. since this locomotive was first used, the mechanism is in good condition; the coupling rod, right side, showed in February, 1905, after a mileage of 29,431 km., a slight crack which has been repaired by welding in a wrought iron steel peg; since this time there has been no cause for any comment, the rod being perfectly sound.

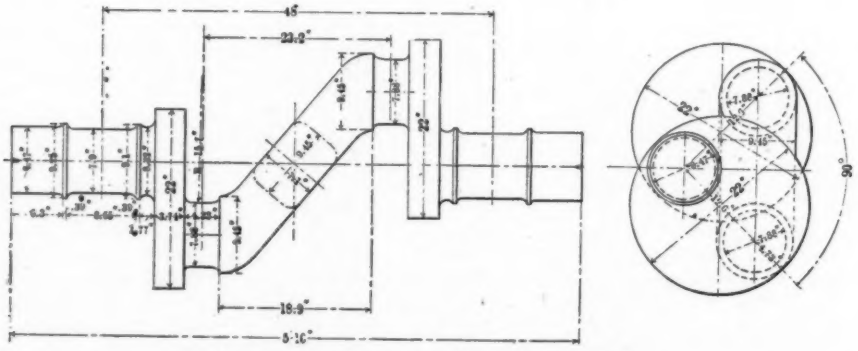
The company afterwards fitted crank-axles of cast steel under three of its locomotives.

(*a*) Under a mixed locomotive of the four-coupled type in June, 1903, a double-crank elliptical axle.

(*b*) Under a four-coupled compound machine with front bogie, No. 324 of the North Belgian system, in March, 1903, an axle with an oblique centre section, also a similar axle under another



CAST STEEL COUPLING AND CONNECTING RODS, NORTHERN OF FRANCE RAILWAY.



CAST STEEL CRANK AXLES, NORTHERN OF FRANCE RAILWAY.

compound locomotive of the same type, belonging to the French system, in March, 1906. The conditions specified were:—

Tensile Tests.—Resistance in kgs. per mm. = 45 to 53 kgs.; elongation per cent. = 15 per cent. at minimum.

Impact Tests.—Square planed bars, 30 mm. section, placed on supports 160 mm. apart, capable of withstanding, without breaking, the shock of fifteen blows of a tup, 25 kgs. in weight, falling from a height of 2·000 m.

These three axles have effected the respective mileages of 138,000, 151,000 and 70,000 km.

The axle mounted under the mixed locomotive alone shows some unimportant fissures, the others being in perfect condition.

GENERAL REVIEW

LEADING ARTICLES OF THE MONTH—CURRENT EVENTS—TECHNICAL INFORMATION FROM ALL SOURCES.

Splicing a Transmission Rope.

Sailors when requested to splice transmission ropes will invariably construct a long splice, but while it serves very well for using with block and tackle, it is not sufficiently elaborate or scientific to give good satisfaction to power transmission. Quite a bit of transmission rope has been spliced in this manner, and it invariably caused considerable trouble in the way of ropes flopping about and jumping out of their grooves because of slight unevenness in its make up and its inability to withstand severe stresses.

A true transmission splice should be of exactly the same diameter as the rope, perfectly free from lumps or depressions; it should have the original lay of the strands and yarns disturbed as little as possible, and the ends should be fastened in such a way that they will not readily come loose and unlock the splice.

Transmission rope is usually made with four or six strands, and as the four strand is the variety most familiar, we will for simplicity confine our splicing directions to the four-strand rope. These directions are given by a writer in the *Engineer, of Chicago.*

The first step in making a transmission rope splice is to ascertain the proper length of rope to be cut. This is done by passing the rope around the sheaves on which it is operated, pulling it up tight with block and tackle, then adjusting and cutting off the ends so that the length of the splice will approximate the lengths given in the following table:—

Size of rope, in inches.								
⅜	½	⅝	1	1⅛	1¼	1⅜	1½	1¾
Length of splice, in feet								
12	13	14	14	15	16	18	18	20

Tie two or three turns of twine around each end where they pass at the middle of the splice. Separate the strands of each end and crotch them together, making sure that the strands are properly alternated, bring the cores C. C. out as shown in Fig. 1, and twist corresponding strands together in order to minimise tangling.

When this has been done, remove the lashing X, unlay 1 to a distance of three-quarters the length of 7 and lay 7 in its place. Then unlay 4 for one-fourth the length of 6 and lay 6 in its place. In a similar way replace 8 by 2 and 5 by 3, keeping the twist and lay of the yarns smooth and regular.

Cores C. C. are next cut off so that the ends just meet and they are then pushed back into space. Now cut off the ends of the strands to a convenient working length of 20 or 24 inches and the splice ought to appear similar to Fig. 2. The next step is to lock each pair of strands. The method pursued for each pair is as follows, taking 1 and 7 for example:—

Unlay the two strands for a distance of about 15 inches and split each in halves back to the point where it meets the body of the rope, see Fig. 3. If, however, the various strands are composed of a core surrounded by a layer of cover yarns, remove the cover yarns from the core, and this constitutes about an equal division of the strand.

Lash the ends of each of these half strands with two or three turns of twine. Then relay half strand 7 in the space left vacant by unlaying the strands, and when 1 is reached, join 7 and the corresponding half-strand 1 by a simple knot in accordance with Fig. 4, pulling the knot taut so that its twist and appearance will be similar to the rest of the rope.

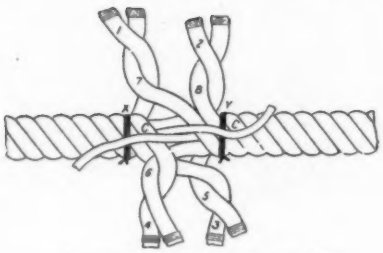


FIG. 1.—SPLICING A TRANSMISSION ROPE.

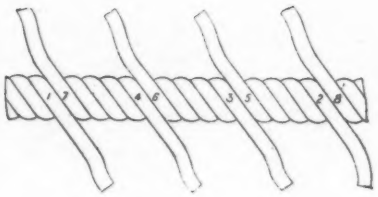


FIG. 2.—TRANSMISSION SPLICE AFTER STRANDS HAVE BEEN CUT.

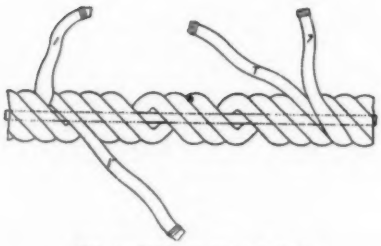


FIG. 3.—SPLICING THE STRANDS.

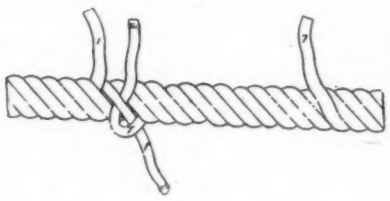


FIG. 4.—KNOTTING THE HALF STRANDS.

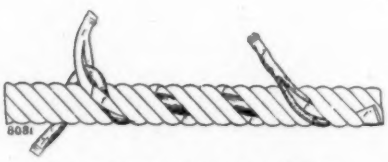


FIG. 5.—LOCKING THE END OF A STRAND.

FIG. 6.—FINAL APPEARANCE OF TRANSMISSION SPLICE.

To lock the end of 7 make an opening with a marline-spike through the middle of half-strand 1, see Fig. 5, pass 7 through this opening and down under the two adjacent strands, keeping clear of the core.

Now take half-strand 1 and start laying it in the same space with 7, passing it under and around 7 three or four times before it gets to 7, so that the two in this way form a whole strand with the yarns laying smooth and even.

The locking of 1 is done in the same way that 7 has previously been fastened by passing it through the middle of 7 and under the two adjacent strands as shown in Fig. 5. Then cut off the ends of the half-strands, leaving about two inches of each protruding in order to prevent their becoming unlocked when the splice stretches. The rope should then look something like Fig. 6.

Parkeston Quay Extension.

The directors of the Great Eastern Railway Company, evidently having no apprehension that the Channel tunnel would cause any appreciable diminution of their Continental traffic, arranged last year for an important extension of the accommodation previously existing at Parkeston. The new quay, now giving promise of early completion, is 1,080 ft. long and will provide for the reclamation of a triangular area affording accommodation for numerous railway

sidings, and buildings destined to be used as transit and locomotive sheds. Three new berths, 320 ft. long each, will be available for steamships, and ample equipment will be installed for the mechanical handling of merchandise in the most expeditious and economical manner.

The quay extension was designed by Mr. John Wilson, M.Inst.C.E., the chief engineer to the company in accordance with the "Hennebique" system of ferro-concrete, all details of which were prepared by Mr. L. G. Mouchel, M.Soc.C.E. (France) of Westminster.

Without entering too minutely into structural features, we may usefully mention the general characteristics of the work. The quay is founded upon about four hundred and fifty ferro-concrete piles driven through a 15 ft. bed of gravel into a stratum of hard cla/ commmencing at the average depth of 44 ft. below quay level. At the back of the structure some eight hundred and seventy ferro-concrete grooved and tongued sheet piles will provide an impenetrable wall for the purpose of holding up the material to be tipped upon the area for reclamation, and above the sheeting a curtain wall will be built up to deck level. Further, a horizontal platform will extend landwards to support and utilise part of the filling so as to counterbalance a considerable proportion of the horizontal thrust of the earth against the quay.

Along the harbour front the quay will be supported on massive ferro-concrete piers. The superstructure constitutes a continuously monolithic framework, comprising columns, walings, bracings, beams and decking, all of ferro-concrete, amply reinforced with steel so as to be capable of withstanding, without injury, any stresses that may be developed.

On the decking of the new quay three tracks for railway trains, and a track for travelling cranes will be provided, in addition to hydraulic capstans and other appliances.

In conclusion we may mention that before final completion of the works, the bed of the harbour in front of the quay will be dredged so as to give the minimum depth of 20 ft. at low water, and as the tidal range is about 12 ft. at Harwich, this will ensure the depth of fully 32 ft. at high water; and thus provide adequately for the future shipbuilding programme of the Great Eastern Railway Company.

The Victoria Falls Bridge.

By G. A. HOBSON, M.Inst.C.E.

THE Victoria Falls of the River Zambesi are situated on the boundary which divides the administrative provinces of North-Western and Southern Rhodesia in the territory governed by the Chartered Company of British South Africa.

The railway reached the bank of the river in May, 1904, the distance from Cape Town being 1,641 miles, and from Beira, on the east coast, 950 miles.

The choice of the site for the bridge was due in the first instance to the late Mr. Cecil Rhodes, and was finally governed by the natural formation of the walls of the chasm, advantage being taken of the minimum distance to be spanned, combined with the soundest foothold obtainable. The position fixed upon is about 700 yards below the cataract. The rock being very hard, the bridge was designed to fit the profile of the gorge with as little expenditure in excavation as possible.

Several types of bridges were considered, but the nature of the situation and the purpose of the work made it obvious that a two-hinged spandrel-braced arch was the one which most completely answered all the requirements of the case. These may be summarised as handsome appearance, rigidity, economy, erection—cantilever-wise—without scaffolding.

The author briefly discusses the merits of three-hinged and braced-rib arches.

The bridge was designed to carry two lines of way of the usual South African gauge, 3 ft. 6 ins. The existing line from Cape Town to the bridge (with unimportant exceptions) is a single track, but a width sufficient for a double line was necessary across the bridge, in order to provide sufficient lateral stability.

In addition to the dead load the forces which the bridge is calculated to sustain are:—

(1) A train on each line of way, consisting of two engines followed by heavy trucks, the weight of the whole train averaging 1·40 ton per lineal foot;

(2) Temperature stresses caused by a 60° F. variation above or below the mean;

(3) Wind-stresses due to a wind-pressure of 30 lbs. per square foot on the train and bridge, or 45 lbs. per square foot on the bridge alone. The pressure is calculated on the entire

* Proceedings of the Institution of Civil Engineers.

area of both arches, and stresses due to unequal distribution of such pressure are allowed for.

The bridge consists of three spans. The end span on the left bank of the river is 62 ft. 6 ins., and the other 87 ft. 6 ins. These spans are composed of braced girders of ordinary type, with horizontal upper and lower chords 12 ft. 6 ins. deep, and divided into square panels. The girders are fixed 20 ft. apart. Connected with the end posts of the central span, they unite it with each bank of the river in a direct and simple manner. The deck is horizontal, and is laid on the top chords throughout.

The central span is 500 ft. between centres of bearings, with a rise of 90 ft. The curvature of the arched rib is parabolic. The panels, twenty in number, are 25 ft. in length. The depth of the girder at the crown is 15 ft., and at the abutment 105 ft. Each main girder stands in a plane at an inclination of one in eight from the perpendicular. The width between the centres of the girders is 27 ft. 6 ins. at the top, and 53 ft. 9 ins. at the springing-level, and between the parapets 30 ft.

To facilitate erection and secure accuracy in alignment, a turned steel pin was inserted at the point of intersection of each vertical and diagonal member with the top chord and arched rib. The pin was designed to be of the least possible weight; as it was not intended to carry an accumulated stress, but only that due to the weight of a single panel, with the addition of a portion of the erecting plant, its weights did not exceed 30 lbs.

Time in erection was thus saved and—once the pin was in its place—confidence in the accuracy of the work so far done was at once established. Reinforcement of the pin by rivets or service-bolts was a matter that could be attended to when all the members constituting one panel were in place, and it was not necessary to wait for the insertion of all the rivets in one particular panel before proceeding with the work of erecting the next.

At the intersection of the end post with the top boom and the first diagonal tie, a large steel pin is inserted through all the plates which compose these members. The pin is 7 ins. in diameter and 7 ft. long, its outer ends being held by means of short links attached to the top booms. To this pin were attached the anchorage-cables during the erection of the bridge. The entire bridge, with the exception of the main bearings, weighs approximately 1,500 tons.

The author describes fully the design and functions of the hinged bearings.

The hinge-pin is 12 ins. in diameter by 5 ft. 10 ins. in length; it is made from a solid steel forging accurately turned all over, and a bolt-hole is drilled through the axis. Regarded in front elevation, the whole bearings, the pins especially, appear to be of very small dimensions, compared with the superstructure they carry. But they are of solid construction, and made of the strongest and toughest materials practicable. The pin itself is subjected to no greater pressure than 2½ tons per square inch.

It is essential, in order that the arch may fall and rise, and the top chord expand and contract with perfect freedom through great variations of temperature, that the hinges be set square to the axis of the bridge. If the pin had no other function to perform but that of supporting the load, it might be set at right angles to the axis of the arch rib, but, were this done, the pin and its fellow in the opp site bearing would not then lie, as they must, in the same straight line, like the hinges of a box lid.

Scarcely inferior to the bearings in importance is the question of the joining of the two arms of the bridge at the centre. Each half of the arch was designed to meet the other with a butt-joint in the arch rib, and when in course of erection the two half-arches met at this joint, their temporary character of cantilevers ceased to be, and the structure was transformed for the moment into a three-hinged arch, the top chord having a clearance or gap left in it of several inches. In order to secure the proper distribution of stress in all members due to the complete structure, it was necessary to impart the stress artificially.

The engineering interest which attaches to the execution of this work is due in a large measure to the remoteness of the site. At the outset it was realised by the engineers that there were many possible risks which would be shunned alike by the British contractor and his workmen, and on the engineers' advice, as far as it was possible to do so, the unknown, doubtful, and incalculable factors were eliminated from the task which contractors were to be invited to undertake. Throughout the preparation of the design the question of erection was considered of primary importance, and every detail was devised to simplify the procedure. In designing the details, consideration had also to be given to the available means of transport by sea and rail, and particularly to the fact that the parts for one-half of the bridge would have to be conveyed across the great chasm by means of some temporary expedient. The

means adopted are described by the author.

The bridge was constructed in accordance with the designs and specifications of the author's firm, Sir Douglas Fox and Partners, and Sir Charles Metcalf, Bart.

The contractors were the Cleveland Bridge and Engineering Co., Darlington.

The Application of Hydro-Electric Power to Slate-Mining.*

By M. KELLOW, Assoc.M.Inst.C.E.

THE slate mines of Wales are situated almost without exception in the counties of Carnarvonshire and Merionethshire.

The mountainous character of the country greatly facilitated mining and quarrying operations in the past, as it enabled the slate beds, which incline at high angles, to be worked by adit levels and horizontal galleries directly from the hillsides, and a small amount of power only was required under these circumstances. The conditions tend to become less favourable every year, as the workings become deeper, and as also mechanical aids in the manufacture of slate tend to become more universal, the requirements, as regards power, must increase considerably.

Though steam has hitherto been chiefly used, there is an abundance of water-power in the two counties, which, if applied, would supply all the needs of the slate industry in this respect. There is little doubt that when the advantages of utilising water-power in conjunction with electric transmission and distribution are generally realised, it will be used almost to the exclusion of any other in slate-mining

The author has designed and installed a hydro-electric plant which contains many features of novelty. The problems covered a wide area, and the application of the principles involved to slate-mining generally are considered. The scheme has been carried out in the Croesor and Cwmfoel valleys in the vicinity of Snowdon, and includes all the essentials of a complete power system.

Details are supplied as to rainfall, catchment area, water-storage (partly by means of a reservoir 12 acres in extent, constructed at an elevation of 1,460 feet above the sea), and a steel pipe-line with its accessories. So far as the author is aware, there is no previous example of so high a head of water as 860 feet having been utilised in the United Kingdom.

Particulars of an original design of air-vessel for use at the bottom of the pipe-line, furnished with hydraulic charging apparatus, to enable it to be filled with air at a pressure corresponding to that of the water, are given.

The author having carried out a large number of experiments on various forms of buckets, nozzles, &c., certain conclusions were arrived at, which are stated in the paper. Efficiency-curves, with different forms of bucket at various peripheral speeds with constant volume, and at constant peripheral speed with varying volume, are given.

The advantages and disadvantages involved by the use of continuous and alternating current respectively, as regards generation, transmission, and distribution, are compared, and a conclusion is arrived at that the three-phase alternating-current system is the one best adapted to slate-mining. Considerations affecting the choice of periodicities are discussed, and 40 or 50 cycles is regarded as the most suitable. The type of generator and method of driving are considered, and conclusions stated.

The conditions under which it is desirable to generate at the distribution voltage, and those under which transformation is desirable, are dealt with. The methods of driving the exciter from the alternator-shaft, and from a separate power-source respectively, are discussed.

The essential qualities in mining plant are stated to be reliability, first-class mechanical construction, and simplicity of operation, and as regards motors these conditions are best fulfilled by the three-phase induction type. The conditions prevailing in slate mills are described, and group-driving by moderate-sized squirrel-cage motors is favoured. The peculiar requirements of winding-up inclined planes, which are usual in slate mines, the character of the traffic, &c., are dwelt upon, and the conclusion is arrived at that three-phase motors are well adapted to the work. The types of motors most suitable to the driving of pumps, fans, winches, &c., are considered. The influence of various starting devices, used in connection with the motors, on the power-factor of the system, is discussed. The advantages of the three-phase

* Abstract of Paper read before the Institution of Civil Engineers.

system as applied to slate-mining are then summarised, and the plant installed for mill-driving, winding, traction, pumping, lighting, &c., at the Croesor Slate Mine is described. Efficiency curves are given relating to every part of the system separately, and in combination.

Electrically-driven Winding Gear and the Supply of Power to Mines.*

By A. H. REECE, A.M.Inst.C.E.

THE operating of mine winding-gears by electricity has up to the present time been little developed in Great Britain, but many plants of considerable size are now in regular use in other countries.

The supply of electricity in bulk in mining districts is also now being actively developed in various parts of the world, and when a cheap supply of energy is available, the use of electricity for heavy work in mines will undoubtedly increase.

The author discusses the questions relating to winding in the first portion of the paper, and in the second portion he refers to various points relating to the cost of electric power in mines.

The advantages of electricity over steam for winding purposes are referred to, and attention is drawn to the use of electrically-driven winding-gear for deep shafts and for two-stage winding. The even turning-moment of electric motors should reduce the wear and tear upon the winding-rope and present advantages over the systems now in use.

The losses through friction at starting with winding-gears are of great importance, as a winding-gear is stopped and started sometimes as often as seventy times per hour. Hence a method of drive which is enabled to start with little friction-loss is certain to prove economical, when compared with steam-engines.

Two-stage winding is no doubt open to many objections, but if it is to be carried out successfully, there is little doubt that the use of electricity would overcome one of the chief objections in avoiding the installation of boilers half-way down the shaft. The use of electrical winding may improve the working with ropes so that it will be possible, by using a factor of safety of 6, to economically wind materials from a depth of 6,000 ft. in a single wind, and thus obviate the necessity for two-stage winding.

The "Koepe" pulley has been largely adopted in Germany with electrically-driven winding-gears together with balanced ropes, and the working of such pulleys appears to give every satisfaction. The work put into heavy cylindrical drums during acceleration may no doubt be recovered during retardation, but if rapid acceleration is required, the maximum horse-power is necessarily very great with cylindrical drums, and is considerably in excess of the normal power required at full speed.

Attention is drawn to the papers by Mr. Behr before the Institution of Mining and Metallurgy and Professor Habets before the Institution of Mechanical Engineers, and to the necessity for studying all the mechanical problems when determining the system to be adopted in any particular mine.

The types of motors which have proved suitable for winding are separately-excited continuous-current motors and asynchronous three-phase motors. In the case of continuous-current motors, the difficulty with starting has been met in some cases by using the "Ward Leonard" system of control. A storage-battery has also been tried. With three-phase motors a liquid resistance in the rotor-circuit has been adopted with satisfactory results.

The author points out that the driving of winding-gears by electricity is not entirely similar to electric-traction problems. There are many new features which require careful consideration. It is essential to study the inertia of suspended loads, the momentum of the winding-gears, the static and dynamic stresses on the ropes, the friction of the shaft as well as the acceleration and retardation.

The great variation in power taken by electrically-driven winding-gears causes undesirable fluctuations in the circuit supplying the gear from the power-house, and, consequently, it is necessary to introduce some method of reducing the effect. The possibility of using storage-batteries is discussed, and the advantages of the fly-wheel system is gone into in detail. This latter system involves the use of a heavy fly-wheel, whose momentum is utilised to give out energy when a heavy load is required, and to take up energy when the load is light. The system has been developed by Mr. Ilgner, of the Siemens-Schuckert Works. Other systems are referred to, and the use

* Paper read before the Institution of Civil Engineers.

of the "Ward Leonard" method of connecting a special generator with the winding-motor in series is discussed.

Figures are given as to the efficiency with the fly-wheel motor-generators. There is loss due to air-friction and windage, and in the case of a 40-ton fly-wheel, with a motor of 240 kilowatts and a generator capable of dealing with about 600 kilowatts maximum, this constant loss was about 17 kilowatts.

The amount of energy available for storage in the fly-wheel should depend upon the period of retardation and the period of decking, when no energy is required to be supplied to the winding-gear from the generator. If the period of retardation and decking is short, it is not necessary to instal a very heavy fly-wheel, but in order to keep the load in the main supply-circuit fairly constant, the additional energy available for acceleration would have to be restricted to the amount stored in the fly-wheel.

The supply of power in mining districts by bulk companies is attracting considerable attention at the present time. To the mine-owners it is purely a question whether they can erect electrical plant and produce electricity themselves at a lower rate than at the prices at which the bulk company are prepared to supply them. The author gives approximate figures as to the capital costs of plants driven by gas and steam-engines, and the running costs. He calls attention to the increased use of gas-engines and of their advantages where coke-oven gas and blast-furnace gas is available. The cost of producing electricity depends upon the load-factor, and the cost should be divided into the following three items:—

(*a*) Interest on capital and depreciation;
(*b*) Fuel;
(*c*) Wages and repairs.

Interest and depreciation is one of the largest items, and in the case of mining companies, as the life of a mine is limited, the interest should be high, and the author shows the effect of an allowance of 10 per cent. on the capital cost upon the price per unit with various load-factors.

The cost of coal and wages depend not only upon the load-factor, but also upon the local prices, and short tables are given to show the effect upon the cost per unit of different prices of coal and different costs of labour.

It is shown that for a mine having a demand not exceeding 2,500 kilowatts, and with coal at 6*s.* per ton, the cost per unit with a load-factor of 20 per cent. is about 0·64*d.*, while with a load-factor of 50 per cent. it is 0·31*d.* The margin with a 20 per cent. load-factor below the price chargeable by a bulk company would probably be so small that it would be better policy to purchase current from them. In the case of the higher load-factor it is doubtful whether a power company could compete with a local generating station.

Researches on the Forms and Stability of Aëroplanes.*

By W. R. TURNBULL.

During a careful study of the history of flying-machines, which the writer has followed to the time of writing, the fact that has most impressed me is that in every one of the proposed machines, both in the tried and untried ones, automatic longitudinal stability is not only a weak feature of the designs but is altogether absent in practically every case.

To a fairly satisfactory extent automatic transverse stability (by giving the aëroplanes a dihedral angle or by keels) is a solved problem, but not so automatic longitudinal stability. On this account the writer took up the laboratory study of aëroplanes with the aim clearly in view of finding, if possible, a type of aëroplane that should have *automatic* longitudinal stability. In this I have been most fortunate, for I have found a type of double curvature aëroplane which not only possesses the elements of automatic longitudinal stability but also gives a very good "lift" and much reduced "drift," when compared with the single curvature surfaces most commonly employed and looked upon as our most efficient lifting aëroplanes.

To make the study systematic let us divide all the possible (*simple*) aëroplanes into five types as follows:—Type I. The plane surface; Type II. The single curvature surface, convex on the under side; Type III. The single curvature surface, concave on the under side (the opposite of Type II.); Type IV. The double curvature surface, concave at the forward portion, convex at the after portion, on the under side; Type V. The double curvature surface, convex at the forward portion, concave at the after portion, on the under side.

In order to further simplify the problem and to make the results with the five different types strictly comparable with one another, I will deal only with surfaces having a rectangular plan-view and in which the width (at right angles to the air current) is twice the length (in the direction of the air current).

Throughout the experiments, therefore, the

* *Physical Review*, New York.

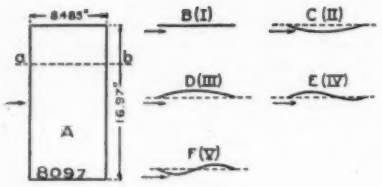


FIG. 1.

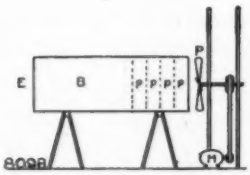


FIG. 2.

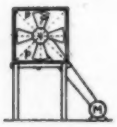


FIG. 3.

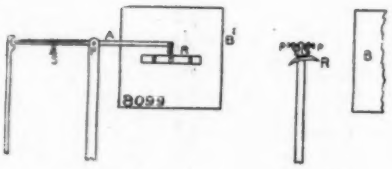


FIG. 4.

FIG. 5.

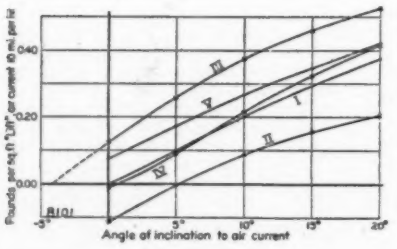


FIG. 6.

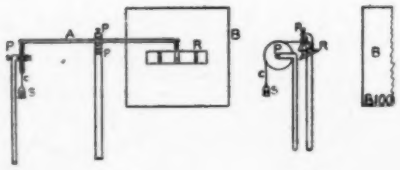


FIG. 7.

FIG. 8.

five following planes are alone used: See Fig. 1, in which the common (developed) plan-view is shown at *A* and the various cross-sections along any fore and aft line *ab* corresponding to the above-mentioned types are shown at *B*, *C*, *D*, *E*, and *F*. The arrow gives the direction of the air current.

In each case the (developed) length is 8·485 in. and the width is 16·97 in., giving a 2 to 1 ratio, with an area of 143·99 sq. in., or practically 1 sq. ft.

These five types were experimented with—first, as to their "lifts" from 0 to 20 degrees; second, as to their "drifts" from 0 to 20 degrees; and third, as to their longitudinal stability, or as to the position of the centre of pressure at all angles from 0 to 90 degrees.

It is a well-known fact that the natural wind varies greatly (even from second to second) in intensity; and it is even a difficult matter to obtain an artificial wind that has absolute constancy; in these experiments, therefore, in order that the results may be exactly comparable with one another, the writer employed a heavy 4-bladed fan-propeller to produce a constant air current, and this fan-propeller was driven by an electric motor whose current was from a storage-battery of ample capacity. This fan-propeller was mounted at one (open) end of a rectangular box 6 ft. long and 22 ins. square, and the speed of the propeller was so adjusted that the air current at the opposite (open) end was exactly 10 miles per hour at a distance of 1 ft. from the end of the box. In the box near the propeller, and for the first half of its length, thin "baffle-plates" were placed to avoid rotary air currents, so that a practically rectilinear air current was produced at the experimental end of the box. The box was further raised from the floor about 2 ft., and this is a most important point in such experiments, for if the box be placed on or near the floor the intake of the fan-propeller is unequal, with a consequent inequality at the opposite end of the box.

Fig. 2 shows a side view, and Fig. 3 an end view of the general arrangement of apparatus in all the experiments, in which *M* is the electric motor; *P*, the propeller; *B*, the long box; *pp*, baffle-plates; and *E*, the end at which the different apparatus for "lift," "drift," and centre of pressure were placed. The air current used in all the experiments was 10 miles per hour, for it was found (as before frequently established) that the "lift" and "drift" of the aëroplanes vary as the square of the speed of the air current, so that it is a simple matter to compute the "lift" and "drift" for any speed (within ordinary limits at least) when the values for a certain speed are known. The variation (if any) for the position of the centre of pressure, with different velocity of air currents, was not determined, as the system was not sufficiently flexible to obtain high speeds.

The aëroplanes experimented with were made of thin tin plate with only a sufficient number of ribs (three) on the upper side, to make the forms absolutely rigid.

The original experiments were made in February to April, 1905, and were further repeated with refined apparatus in June and July, 1906.

"*Lift*" *Experiments.* — The apparatus for obtaining the "lift" (or vertical component of air pressure) of the aëroplanes, was mounted in such a way that the centres of the aëroplanes were 1 ft. from the free end of the box and exactly in the middle of the opening.

Fig. 4 shows a side elevation, and Fig. 5 an end elevation, of this apparatus which is simply a common balance arm, *A* (mounted on horizontal pivots, *pp*), with the aëroplane, *R*, mounted on one arm, and with a movable scale-pan, *S*, on the other arm to measure the loss of weight when the air current passes.

Throughout the experiments the aëroplane, *R*, was inclined at angles of 0, 5, 10, 15, and 20 degrees with the horizontal, and the corresponding settings of the scale-pan, *S*, to make a balance when the air current passes, were recorded.

In this way a series of readings were obtained which are plotted in Fig. 6, the average of several readings for each inclination of the aëroplane being used to determine several points on the curves.

It will be noted that the *comparative* lift of Type V. at small angles is slightly greater than at large angles, by comparison with any of the other four types.

It will also be noted that the best "lift" (*per se*) is given by the single curvature surface, concave on the under side, and the poorest by the single curvature surface, convex on the under side; but in selecting the best form of aëroplane for use in an aërodyne other factors enter, as will be seen when these results are considered in connection with the "drift" and centre of pressure experiments.

"*Drift*" *Experiments.*—The apparatus for measuring the "drift" (or horizontal component of the air pressure) was mounted in such a way that the centre of the aëroplane was 1 ft. from the free end of the box, and exactly in the middle of the opening.

Fig. 7 shows a side elevation, and Fig. 8 an end elevation of this apparatus, which is simply a balance arm, *A*, mounted on vertical pivots, *pp*, with the aëroplane, *R*, mounted on one arm, and with the other arm attached to a cord, *C*, passing over a frictionless pulley, *F*. The scale-pan, *S*, in this case, being attached to the other end of the cord, and the "drift" being measured by the adjustment of weights on the scale-pan.

As in the case of the "lift" experiments, the aëroplane, *R*, was successively placed at 0, 5, 10, 15, and 20 degrees, and the corresponding weights to make a balance, when the air current was passing, were recorded. For each reading the "drift" of the arm without the plane was subtracted from the reading. I might mention here that a compound balance (such as was used by Maxim in his experiments) for obtaining both the "lift" and "drift" with the same apparatus was first tried, but the method of employing separate pieces of apparatus for each form of experiment was found to be far more sensitive and accurate.

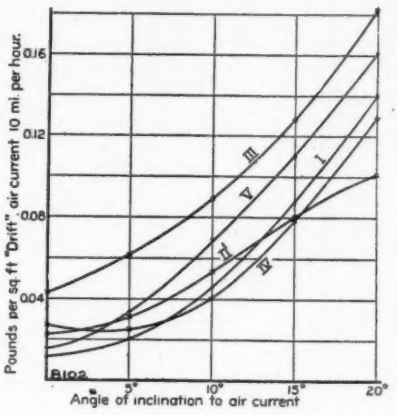


FIG. 9.

The data of the experiments on "drift" are plotted in Fig. 9, and on comparing them with the "lifts" of Fig. 6 we have some interesting results. It is noted that the single curvature surface (Type III.) concave on the under side, not only has the largest "lift," but also the largest "drift," while the "drift" for Type IV. (concave in front, convex in the rear, on the under side) actually decreases from 0 to 4 degrees. For equal drifts we have the table given in the second following section, and from this table we see that for equal "drifts," Type IV. at 10 degrees has more than double the "lift" of Type III. at — 0·7 degrees. This fact has more than usual interest, because it will be shown in the next section of this paper that Type IV. has automatic longitudinal stability from 90 to 0 degrees, while Type III. has longitudinal instability between the angles of 28 and 0 degrees.

The decreasing drift of Type IV. between the angles of 0 and 4 degrees has also something to do with the soaring of birds, in the opinion of the writer, but this will be further referred to in another section.

In the two foregoing sections the writer has measured only the vertical component of air resistance ("lift") and the horizontal component of air resistance ("drift"). I have not followed Lilienthal's* method of plotting a resultant force (the total air resistance) from the "lift" and "drift" and afterwards resolving this resultant into a "normal" and "tangential" force; for these latter mainly apply in the case of an aëroplane falling through the air, at the

* "Der Vogelflug als Grundlage der Fliegekunst," Berlin, 1898.

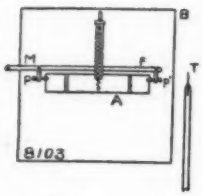


FIG. 10.

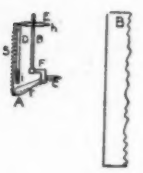


FIG. 11.

same time moving forwards along a course at a certain negative angle with the horizontal.

While Lilienthal's method is interesting when applied to his assumed slope of a bird's wing during the down stroke, it is applicable only to artificial flight when it is sought to solve that problem by beating artificial wings, and it is, in general, not applicable to the problem of artificial flight with fixed aëroplanes driven horizontally through the air at a certain positive angle of inclination.

Centre of Pressure.—Thorough in many ways as Lilienthal's results on "lift" and "drift" are, he unfortunately passed all too lightly over the more important question of the centre of pressure, and while Joessel, Kummer and Langley experimented on this all essential problem, their experiments invariably stopped short of those critical angles between 25 and 0 degrees, which are by all means the important ones in the study of natural and artificial flight.

The first method used by the writer for measuring the centre of pressure, was the usual one of the eccentric plane with counterpoising weight (used by Langley and others, see "Experiments in Aërodynamics," Langley, pp. 89—93, 1902), but its decided limitations were soon apparent and a delicate counterpoising spring was substituted, with excellent results, for aëroplanes whose centres of pressure advance far in front of their centres of figure.

The counterpoising spring is limited however to use with certain aëroplanes between about 35 and 0 degrees. so that a use of both methods is necessitated for a complete set of readings between 0 and 90 degrees.

The aëroplanes to be tested were ruled with lines (parallel to the leading edges) at distances of ½, 1, 1½ ins., etc., in front of (and behind) their centres of figure, and at the points where these lines reached the side edges of the aëroplanes screw clamps were successively placed. The clamps being provided with pivot-holes for the insertion of the pivots of the supporting frame.

Figs. 10 and 11 show front and side elevations of the apparatus as employed with counterpoising spring; *M* being the arm holding the supporting frame, *F*. *F* carries small arms which are adjustable along its length to allow of use with different widths of aëroplanes, and these small arms carry the pivots, *pp'*, which carry the aëroplane under test, *A*. The frame, *F*, also carries a vertical rod, *B*, to which is clamped at any desired height, the block, *E*. *E* houses a horizontal rod, *H* (adjustable horizontally), which carries at its end a long sensitive spring, *S*, acting as a counterpoise for the unbalanced weight of *A*.

S is protected from the air-current by a shield, *D* (V-shaped in plain cross-section), and a small pointer soldered to *S* plays over the scale, *i*, near the bottom of *D*.

The dotted line, *C* (Fig. 11), shows the (imaginary) chord of the curvature of *A*, and in every case the upper side of the rib, *r*, is made parallel to this chord so that the angle which *A* makes with the horizontal may be read by means of a vertically mounted transparent protractor (shown in Fig. 10 at *T*) by sighting through the protractor along the upper line of the ribs.

When using the aëroplanes with a counterpoising weight the spring with its accessories was removed, and the counterpoise secured by attaching a flat leaden weight to the upper side of the aëroplane under test.

Both methods of experiment were used as the circumstances of each setting of the pivots demanded, and where the results of the two methods "overlapped" the accordance of the readings was satisfactory.

I have unfortunately been unable to obtain the original papers of Joessel and Kummer, so that I do not know of their methods of experimenting, but Langley mounted his counterpoised eccentric planes on the arm of a large whirling table, and obtained (from a pencil trace) the angle corresponding to a certain setting of the side pivots, and it is just here that the superiority of the method above described (with stationary aëroplanes and artificial air

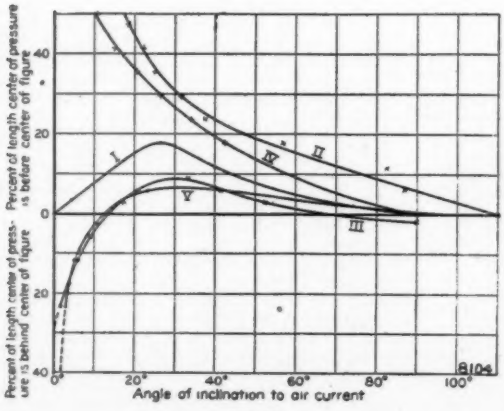


FIG. 12.

current) is most pronounced; for with several types of aëroplanes (viz: Types I., III. and V.) there is not one angle, but two corresponding to the one setting of the side pivots.

To illustrate this let us take the example of plane No. III., with pivots on the centre line. By Langley's method the only reading obtained is that at 90 degrees; but by the writer's method, the reading for 90 degrees is also obtained if the plane is untouched, but if the rear edge of the plane is supported loosely between the thumb and forefinger of one hand, and carried to a position nearer the horizontal, we find a second angle (at 12½ degrees) where, if the plane be slightly depressed, the rear edge will be strongly depressed, and if slightly raised, the rear edge will be strongly raised, and we here have a second angle (capable of accurate measurement) *where the centre of pressure again corresponds to the centre of figure.* Of course, in place of the thumb and forefinger, a metal yoke with adjustable set screws could be similarly employed and could be vertically raised until this second critical angle was reached, but the thumb and forefinger furnish a sensitive index of the approach to this angle, and the accuracy of the results are excellent.

The results of these experiments are given in Fig. 12, where angles with the horizontal are plotted as abscissæ and centres of pressure (in percentage of the side of plane); both before and behind the centre of figure, are ordinates.

In the case of the plane (Type I.), we note that the centre of pressure steadily advances in front of the centre of figure until the critical angle of 26 degrees is reached, when the centre of pressure rapidly retreats to the centre of figure as the angle becomes smaller and reaches 0 degree.*

In the cases of Types III. and V. this reversal takes place at somewhat near the same angle, but at a much shorter distance in front of the centre of figure, the centre of pressure then rapidly retreats behind the centre of figure, which it passes at about 13 degrees. Type III., on account of its excellent "lifting" qualities, is the aëroplane that has been almost universally used in artificial flight experiments, but this reversal in the position of the centre of pressure, with its consequent utter lack of longitudinal stability, is doubtless responsible for nearly all the accidents that have occurred in aëroplane experiments; Lilienthal and Pilcher lost their lives through ignorance of this reversal, and Langley's large machine was also probably wrecked through a lack of knowledge on this point.

For Types II. and IV. we have the remarkable result that the centre of pressure steadily advances to the forward edge of the plane, where, by reference to Fig. 6, we note that the lifts are both negative. We therefore have, for these two types, the condition of automatic longitudinal stability for all positive angles and "lifts."*

Significance of these Results for Artificial Flight.—In comparing the relative merits of these five types from the view-point of artificial flight, we must not only take into consideration their stability curves, as shown in Fig. 12, but also compare the "lifts" and "drifts" as given in Figs. 6 and 9.

We then find that for the two aëroplanes of automatic stability, Type IV. has a much superior "lift" to Type II. and a lesser "drift" between the angles of 2 and 15 degrees; which are the important ones for artificial flight.

As pointed out above, Type III. has been almost exclusively used in artificial flight, but when it is compared to Type IV. we see that it has an utter lack of stability, while Type IV. has automatic stability, and while, at first sight, Type III. has the superior lifting qualities it also has a large "drift." As a matter of fact the "lift" of Type IV., as compared to its "drift," is superior to the "lift" of Type III., as compared to its "drift," *for certain angles*, as *per* the table below, in which the respective values of "lift," at their corresponding angles, are given *for equal "drifts"* in each case.

Type IV.		Type III.		Lift. IV. ÷ Lift III.
Angle.	Lift.	Angle.	Lift.	Ratio.
Degrees.		Degrees.		
20	·417	15·1	·459	·91
19	·400	13·7	·439	·911
18	·381	12·4	·416	·916
17	·364	11·1	·395	·921
16	·346	9·6	·368	·941
15	·325	8	·331	·982
14	·303	6·5	·297	1·020
13	·283	4·6	·249	1·136
12	·261	2·9	·204	1·280
11	·240	1	·154	1·558
10	·216	−0·7	·105	2·055

From this table it appears that *for equal drifts*, Type IV. at 10 degrees has actually double the lifting value of Type III. at −0·7 degrees.

Lilienthal's principle for artificial flight was certainly well taken, viz., "stability first, propulsion afterwards," but we cannot revise the history of experimental aëronautics without insisting on this revision: automatic stability first, and always propulsion so soon as prime-movers become sufficiently light.

Aëroplanes of Type IV. give the essential elements of automatic longitudinal stability;

* In the case of *a square* with 9 in. side the writer found this critical angle at about 18 degrees, and it is just about this point where the curves of Joessel, Kummer, and Langley (who all experimented with square planes) cease. Joessel inferring that the law formulated by him, $c = 0{\cdot}3\,(1 - \sin a)\,L$ held good until 0 degree was reached.

* Ahlborn, "Illus. Aeron. Mitteilungen," 1904. States *that only slightly convex* aëroplanes (Type II. of the writer's experiments) possess unconditional automatic stability, but his statement seems to be based on incomplete observations rather than on experiments.

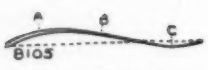


FIG. 13.

FIG. 14.

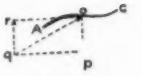


FIG 15.

FIG. 16.

the well-established principles of the "dihedral angle" and keels give automatic transverse stability; and gas engines, now approaching 3 lbs. per h.-p. give the required lightness of prime-movers.

In these three principles, therefore, the problem of aërial navigation is theoretically solved. It now remains only to so combine these three essentials in practical form, to solve the problem from an engineering standpoint.

I could hardly insist that aëroplanes of Type IV. are the only ones possessing the all important properties of automatic stability, but among simple aëroplanes (*i.e.*, those having zero, single, or double curvature), my laboratory experiments have clearly shown that *Type IV. is the only aëroplane having at the same time automatic longitudinal stability combined with excellent lifting properties and exceedingly small drifting properties*, for all angles that would probably be utilised in artificial flight.

Significance of these Results to Natural Flight.—Lilienthal in his valuable book* has given an able analysis of bird flight, but he has made one assumption (p. 76) which is hardly tenable, viz.: that the slightly concave surface is the form most like that of the bird's wing.

Neither my experiments nor a general consideration of the structure of the bird's wing lead to this conclusion.

The average cross-section of a bird's wing when extended consists essentially of a forward portion, *A*, Fig. 13, of rigid formation, with a central portion, *B*, of partial rigidity, and a rear portion, *C*, of extreme flexibility.

While this formation certainly varies from the portion nearest the body to the extreme tip of the wings, I think it will be generally conceded that Fig. 13 fairly represents an average cross-section of an average bird's wing (during the down stroke).

If now we conceive this wing in rapid up-and-down strokes passing through a resisting medium, such as the air, it requires only a rudimental conception of mechanics to infer that in the up stroke the cross-section assumes the form shown in *AC*, Fig. 14, while in the down stroke a form similar to that shown in *AC*, Fig, 15, would be necessitated.

In each figure, *op*, gives the direction of the wing motion in each case, while *or* represents the absolute direction of the air current. It is obvious that the *relative* movement of the air particles is roughly represented by *qo* and it is equally obvious that a wing, of the type described in connection with Fig. 12, would be forced into the approximate forms shown in Figs. 14 and 15—*corresponding to the two Types II. and IV., both of which have been shown by the laboratory experiments to have automatic longitudinal stability.*

If then we accept this reasoning, it is proved that in bird flight the two forms assumed by the wing *both have automatic longitudinal stability*, that in the up stroke the "lift" (negative in this case) is a minimum (see Type II., Fig. 6) while the "drift" is small (see Type II., Fig. 9) and that in the down stroke the "lift" is excellent (see Type IV., Fig. 6) while the "drift" is a minimum (see Type IV., Fig. 9).

From this it is seen that the laboratory experiments are in full accord and give a most rational explanation of the wonderful properties displayed in the flight of a bird.

For soaring or sailing flight the most probable form of the bird's wing is that shown in Fig. 16, which is simply a less accentuated form of Fig. 15, due to the lessened air pressure on the under side of the wing.

The resolution of forces as shown in this figure gives a perfectly rational explanation of soaring flight, by which a bird is supported and at the same time advances against an ascending current of air, for in working out the "lift" and "drift" under these conditions we find that *OR*, the resultant, is in advance of the normal to the chord of the double curvature, and we have for the forces acting upon the surface the vertical component *ON* equal to the weight of the bird and the tangential force, *OT*, which furthers, instead of hinders, the advance against the air current.

It has been frequently shown by delicate anemometer measurements, &c., that no natural wind is steady, but that the air currents have a pulsating movement, with pulsations varying sometimes several times in a second. The soaring bird can instinctively feel these pulsations, and can make excellent use of them by slightly inclining the extended wings more or less to the pulsating current, and can thus

* "Der Vogelflug als Grundlage der Fliegekunst," Berlin, 1898.

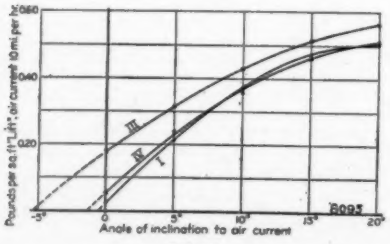


FIG. 17.

maintain or increase its height, while at the same time it slowly advances against the air current.

Experiments from many sources (Lilienthal and others) have shown that there is also in natural winds, near the surface of land or water, an ascensional trend of about three degrees, and this further facilitates the soaring of most birds.

Referring again to the automatic stability of birds, the extended tail in many species is undoubtedly a valuable *auxiliary* to the maintenance of automatic longitudinal stability; but it is quite evident from a consideration of several species in which the tail is almost lacking (*e.g.*, the wild duck) that the tail is not essential, and this further accentuates the idea that the primal and main cause of automatic stability in bird flight is to be found in the wing-forms shown in Figs. 14 and 15.

Lilienthal's close adherence to his conception of the natural wing-form was the probable cause of his death, for in all of his soaring machines (and in a great majority of soaring machines that have since been built) the single concave surface has alone been used, and with it of necessity (see Curve III., Fig. 12) automatic stability is impossible, and "stability" is only obtainable by the agility of the operator in moving his body or an auxiliary steering aëroplane.

The Influence of an Underplane.—In considering the subject of aëroplanes used in artificial flight, it occurred to the writer that the lifting properties of aëroplanes might be considerably increased by allowing the aëroplanes to skim close to an underplane, such as a level piece of land or close over water.

As is shown in Fig. 17, a considerable increase in "lift" really occurs (due no doubt to the wedging action and consequent compression between the aëroplane and underplane) and at first sight it would seem a valuable consideration in the design of an aërodyne; since it is just when arising and alighting, when the speed would be comparatively low, that the maximum "lift" would be desired. However, many other modifying conditions must be considered, since screw propellers must have a considerable diameter and their central line of thrust must be in line with the aëroplane resistance; and, moreover, the "drift" is also considerably increased with an underplane and the centre of pressure is shifted, in general, considerably farther "aft" than it would be in free flight, introducing serious difficulties in balancing. These various drawbacks of the underplane may be overcome (*e.g.*, by superimposed planes), but it is well to draw attention to them.

In Fig. 17 the "lift" curves, with an underplane, are given for Types I., III., and IV. The readings with the underplane were obtained with the apparatus shown in Figs. 4 and 5 under the same conditions as before, but with an underplane (a large drawing board) placed horizontally one-half inch below the rear edge of the aëroplane in its mean position of balance.

It is needless here to go into details concerning the influence of an underplane on the "drift" and centre of pressure of aëroplanes, but the writer's experiments with "lifts" may be summarised as follows: (1) With plane surfaces (Type I.) and double curvature surfaces (Types IV. and V.) the *relative increases* of "lifts" with an underplane are greater than in the case of single curvature surfaces. (2) Under certain conditions the "lift" may be nearly doubled by an underplane very close to the rear edge, but in general, the influence nearly disappears at a distance above the underplane equal to about one-third the length (in the direction of the air current) of the aëroplane.

In conclusion, with regard to the general design of a practical aërodyne, I can only say that the proportion of parts is an essential feature which must be worked out by outdoor experiments, preferably over a sheet of water.

The laboratory experiments, described in this paper, can give but little help in the proportioning of parts, but they clearly show the type of aëroplane to be adopted and the type to be distinctly avoided. On the one hand we have Type IV., with its great advantages of *automatic longitudinal stability, excellent lifting properties and exceptionally low "drift,"* and on the other hand the long-adopted aëroplane with single concave curvature, which, while it has most superior lifting qualities, has also a most serious "drift" (for high speeds particularly to be considered) and *above all in importance, most treacherous longitudinal stability.*

A trifle in added speed gives the former type equal "lift," with the latter (since the lift and drift increase with the square of the speed), so that it should be an easy matter for a designer to choose unhesitatingly between the two.

British Destructor for America.—The City Council of Seattle, Washington, U.S.A., one of the most progressive Municipalities on the Pacific Coast of America, recently passed an Ordinance empowering the City Engineer to negotiate for the erection of a large destructor plant of the "Meldrum" simplex type. The order for this plant has now been placed with Messrs. Meldrum Bros., Ltd., Timperley, near Manchester.

The first successful destructor plant of British make erected on the North American Continent was that installed some two years ago for the Corporation of Westmount, Montreal, and the tests there carried out prove the "Meldrum" simplex destructor to be equally well adapted to deal with American refuse as with English or Colonial refuse.

NOTES AND COMMENTS.

The increasing interest that has been shown in recent years by engineers in the problems of aërial navigation has been in no small degree responsible for the speculations of the man in the street, who talks glibly of travelling by flying machine in the not far distant future. Fiction has supplied another factor in stimulating such speculation into one of the most fascinating departments of applied mechanics. To those, however, in possession of the natural caution which is associated with scientific habits of thought, and which is so pronounced in those who have had the advantage of an engineering training, investigation of a practical character in aëronautics has acted as a curb on the imagination, and has revealed the difficulties which surround any such solution of the problem as that imagined by the irresponsible dreamer. Outside the uses to which ordinary balloon ascents have been put, such as, for example, purposes of observation in military and meteorological matters, in no sense can investigation claim to have set the question even one step nearer the commercial utilisation of flying machines.

It would be folly to deny, however, that much useful work has very recently been done in the development of the science of aëronautics, although, as is pointed out by Mr. W. R. Turnbull, an account of whose valuable researches appears in another portion of this paper, "it is simply amazing when one considers the thousands of scientific workers in all parts of the world devoting their time to refinements and ultra-refinements of well-known physical laws, to note how few persons are willing to take up the laws of aërodynamics and reduce them to an exact science."

"The field that is open is alluring, even fascinating, and there is more scope for original research, and more chance for reward than in many of the beaten tracks; and yet the student of science still holds aloof, preferring to pass and repass over the footsteps of others."

Just as soon as the mechanical engineer can command at his drawing-table full data concerning the lift, drift and centre of pressure of aëroplanes, the thrust and efficiency of different forms of air propellers, the strength and suitability of materials, and the complete elements entering into the longitudinal and transverse stability of an aërial machine, considered as a whole—just so soon, and not before, can we reasonably expect the problem of aërial navigation to be really solved.

The more or less successful attempts of M. Santos-Dumont, the experiments of a less pretentious, but none the less interesting, character, undertaken by Lilienthal, Pilcher, Chanute, and the Brothers Wright, in connection with the design and working of aëroplanes, and finally the investigations undertaken by Baden-Powell into the theory and practice of kites, bear ample testimony to the progress that has been made.

By including the names of Maxim and Langley and the flying machine proper in the category of investigators, the main avenues along which research is proceeding will be indicated.

Up to the present moment the motives governing those who have devoted attention to the problem have been probably separated from any notion of pecuniary reward. The recent offer of prizes by newspapers and others, however, has had the effect of encouraging experimenters to enter the field of competition, many of whom, we fear, judging by the recent trials of model air ships held at the Alexandra Palace under the auspices of the Aëro Club, have but the most rudimentary notion of the real nature of the problem involved, and so far from having advanced the science would appear by their grotesque efforts to

have failed to impress the public that they had taken the matter at all seriously.

It cannot be too strongly urged that any real progress in the problem of artificial flight is not to be made by the perpetrator of mere whimsicalities, but only by patient research along scientific lines, such as are indicated by the efforts of the investigators above mentioned.

The Aëro Club is nevertheless deserving of the highest commendation for their forward policy in inaugurating such a show, and it is to be hoped that future efforts on their part will be productive of more encouraging results.

The German Navy at Home.—The headquarters of the German Navy are nominally, says *Chambers's Journal*, at Kiel. But Kiel is on the Baltic; and when the canal was cut, in order to join its excellent harbour to the North Sea, German Dreadnoughts had not been thought of, and there is no doubt that the "mouse-traps" of the Baltic will be as dangerous to them as to the war vessels of other nations. There are plenty of accidents to the existing ships as it is; and the canal is only 70 ft. in width at the bottom, with a depth of 30 ft. Besides, it takes nine hours to pass through its sixty miles of length. A moment's reflection will convince anyone that the North Sea will be the battle-ground of the German Fleet; and it is to the North Sea, therefore, that we must look to see the German Navy as it really is, and also as it will become. The German North Sea coast is not much more than a hundred miles as the crow flies, and anything more dreary and uninteresting it is impossible to conceive. Wilhelmshaven, the naval harbour, lying behind its 20 ft. high dykes, dates only from 1855, when Prusssia acquired the site from Oldenburg and started the making of a Navy. At that date there were only a few fishermen's huts in what is now called the suburb of Heppens. First one harbour was cut out of the land, then another, and then a third. Not until the present Emperor, however, did the work progress with the giant strides it is doing now. Since his advent the expenditure on the harbours, forts, strategic railways, barracks, docks, and other buildings must have been enormous. And all this does not appear in the German Naval estimates. The entrances to the harbour are through locks, for there is not enough water at low tide to serve. A large torpedo-boat harbour outside the dykes has only recently been enclosed from the Jahde-Busen, an inland circular bay about sixty miles in area formed by an inundation some hundreds of years ago, a great part of which is left dry at low water. An additional inland harbour is also being scooped out which will have a separate entrance to the channel of the Jahde. A large number of dredgers have to be kept constantly at work in order to keep this channel free. Even now the largest battleships can only enter it with safety at high tide. No wonder the German Navy is casting hungry eyes on Holland. Wilhelmshaven contains about 30,000 inhabitants, all of whom are in some way or other connected with the Navy. Kiel is under the supreme command of Prince Henry, and Wilhelmshaven under Admiral Bendemann. The shore batteries (many of which are inland), and military as well as naval works, are all controlled by them. When the harbours of Wilhelmshaven are complete, Emden (the most westerly port) will be taken in hand, and the existing commercial canal to the former place deepened and widened into one for battleships. There will thus be less danger of a successful blockade by a hostile fleet, for the two ports are fifty miles distant, and the coast in between is unapproachable.

ELECTRICAL ENGINEERING NOTES.

By ANDREW STEWART, A.M.I.E.E.

The Direct Current Series System.

Engineers in general will no doubt be interested in the paper recently read by Mr. J. S. Highfield, to the Institution of Electrical Engineers, on this subject. It has been given such prominence that some mechanical engineers have not unnaturally asked, are the orthodox systems of electric transmission doomed to early extinction? Such fears are, however, groundless, as, notwithstanding the eloquence of its few advocates, the series system is, and will in all probability remain, characteristic only of the installations carried out by M. Thury. It is a system which this gentleman has made his own, and in the hands of one less able and plucky, would have remained merely of academic interest.

It is a striking testimonial to the success which has attended M. Thury's efforts, that there should be some fifteen installations dealing with from 175 to nearly 6,000 h.p., over distances varying from 15 to 224 miles, at pressures of 2,600 to 57,000 volts, all in satisfactory operation. They are located chiefly in Switzerland, Italy, France and Spain, though Russia and Hungary can show examples.

The system differs from the orthodox system of electric distribution, in that instead of a constant voltage, and a current which varies in proportion to the load, quite the reverse is the case. The voltage varies in proportion to the load, and the current is constant, no matter what the load may be.

The initial difficulty is that the usual direct current machine cannot be made to give the high voltage necessary to secure economical transmission of power, so several are employed, connected in series, each one contributing some portion of the line pressure. Assuming, for instance, that a load of about 2,400 kw. is to be transmitted (a little over 3,000 h.p.) and a line pressure of 12,000 volts is adopted, the line current would be fixed at 200 amperes, and three generators each capable of giving 800 kw. at a pressure of 4,000 volts would be used.

Fig. 1 shows diagrammatically the system of generators and motors. If the load on the generating station was only 1,600 kw., one generator would be shut down, and its terminals *short circuited* by a switch. If the load fell still further, say to 800 kw., only one generator would be used. So far this shutting down of the generating machines as the load falls off, is the usual practice in all stations, but the difference with the "Thury" direct current series system is that the shutting down of the generators involves no reduction in the line current, which remains at 200 amperes, but the line pressure is steadily reduced from 12,000 volts to 8,000, and to 4,000 volts. It is just as if, with a steam engine and boiler, we reduced the boiler pressure as the load on the engine fell

off, and continued to evaporate the same amount of water at light loads as we formerly did at full load.

Such a system of generation and transmission involves one or two distinct departures from general practice.

At present a short circuit has terrors which few other things have for the electrical engineer, but with the direct current series system, short circuiting the generators and motors when they are not wanted, becomes the proper mode of control. For instance, if one of the generators shown (Fig. 1) is unnecessary, its terminals are short circuited, *i.e.*, bridged across, and it is stopped. The current then passes across the short circuiting switch, and not through the machine.

The same applies to any of the motors. If one is not wanted its terminals are bridged across, and it is no longer capable of supplying power, yet the main circuit is uninterrupted.

A motor is started up by opening, not closing, a switch. Indeed, all the usual operations in an electrical installation are reversed by this system.

The outstanding disadvantage of this system is, that as the line current remains constant, so also do the line losses. With the usual constant voltage system, the transmission losses are a maximum only at full load, and these losses fall off rapidly as the load is reduced, as they are proportional to the square of the current. With a series system the total losses remain the same, hence they become a large proportion of the power transmitted at light loads, and as full load can only be maintained for a small portion of the twenty-four hours, the importance of this feature must not be overlooked, especially as the simplicity which is possible by its use is of little financial value. Of course the "Thury" direct current series system has so far only been developed in connection with water power plants, and in such cases the efficiency of transmission is not so serious as in the case of a station where any line loss represents a direct monetary loss, due to the additional fuel consumption.

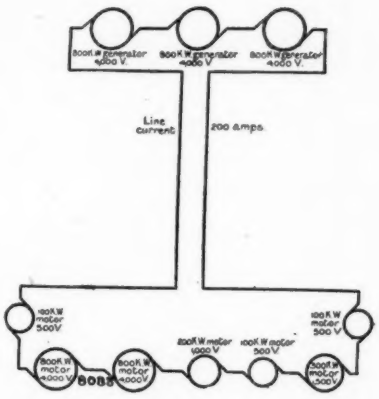


FIG. 1.—DIAGRAM OF SERIES DIRECT-CURRENT SYSTEM.

Another feature of such plants is that the engines, dynamos, switchgear, &c., must be effectively insulated from earth, and these parts of the installation are therefore carried on earthenware insulators, while the floors are of an insulating material. All this is essential, as the attendants must handle the brush, gear, &c., of the generators, which have a voltage of 2,000 to 4,000 above the earth potential, and if the floor were not an efficient insulator the possibilities might be serious.

Electric Power in the Iron and Steel Industries.

During a recent visit to a number of ironworks, the writer was impressed with the growth of interest in electric driving. There are hardly any electrically driven rolling mills of large size, though electricity is largely used for small mills, for live rolls, and auxiliary machinery. Judging, however, by the interest displayed in the question, one may safely assume that at no distant date we shall find some very large mills equipped for electric driving, especially as there is a good deal of experience available on the Continent of Europe.

Strange to say, the United States of America appears to be very backward in such developments, there being hardly any installations of note. Germany and Belgium present, on the other hand, examples of considerable magnitude. This may be explained by the fact that owing to the high cost of labour in the United States, the efforts of iron and steel works managers have been concentrated on the development of labour-saving appliances, to the neglect of power-saving apparatus. Quite the reverse is the case on the Continent, where labour is cheaper, and fuel is sometimes, though not always, dearer, hence the tendency is to exaggerate the importance of fuel as a factor in the cost of production.

The Burbach Iron and Steel Works, one of the best organised works of its kind in Germany, has recently added considerably to the generating plant, and further extensions are now in progress.

The original generating station contained three "Deutz" gas engines fed with blast furnace gas, the collective output being about 1,700 h.p. The second extension consisted of a "Nuremberg" gas engine, and a two collector dynamo, giving 240 volts. for the lighting and power circuits adjacent to the generating station, and 480 volts. for more distant circuits. The output of this generator is 1,300 h.p., but unlike the earlier units this gas engine is operated by coke oven gas.

Still another unit is to be installed, consisting of a "Nuremberg" steam turbine of 1,250 h.p. driving two dynamos, each giving their full output at 240 volts., but of course they may be paralleled with the two commutator machine already noted and used to supply distant parts of the works at 480 volts.

The works contain 290 electric motors aggregating over 2,500 h.p., 4,000 incandescent and 300 arc lamps.

One of the most interesting applications of electric power is a 380 h.p. motor coupled to the finishing train of the rolling mill. It is arranged for shunt regulation between 232 and 300 revs. per min. The coke ovens are served by an electric locomotive handling trains of seventeen to twenty coke barrows.

The largest electrically-driven *reversing* mill, and, as far as is known, the only reversing rolling mill in the world that is electrically driven, is installed at Erzherzogliche Friedrich Huttenwerke, where a four-stand mill with rolls of an average diameter of 2 ft. 6 ins. is used in producing blooms and rails, the latter up to 160 ft. long, and girders 14 ins. deep and 75 ft. long, weighing 190 lbs. yer yard. The ingots from which they are rolled weigh two tons. Such a mill obviously requires a very large engine or electric motor, as modern mills dealing with similar work in this country, such as at Cargo Fleet and Bell Bros., have engines of ten to fifteen thousand horse power, and naturally a good deal of scepticism is displayed regarding the ability of the electric motor to deal with powers of this order, especially when required to reverse and accelerate in two and a half to three seconds. One difficulty with the electric motor is the large diameter of the armature and commutator of a slow speed motor of this size, and the consequent large store of kinetic energy in the moving mass, so that retardation and acceleration would take a longer time than was permissible and the output of the mill would suffer.

This difficulty is overcome at the Frederich Huttenwerke by using three motors, thus obtaining the light moving masses desired. The collective power of the motors is 10,350, and when in operation the load varies from about 4,000 to 10,000 h.p. The maximum speed of the rolls is 110 revs. per min., and heavy rails and girders are passed about twenty times. A current of 8,000 amperes at 1,000 volts. is required at the first pass, which falls to 5,000 amperes at the last.

Such large fluctuating currents could hardly be borne by the generating station, so an "Ilgner" converter is used. This consists of a three-phase

motor capable of giving 2,500 h.p., but with an overload capacity of 100 per cent. for short periods. It is coupled by flexible couplings to two generators capable of giving 4,500 kw. each, a total of 12,000 h.p. Each generator is coupled in series and gives 500 volts., so that the secondary pressure available for the mill motor is 1,000 volts. Each generator has a cast steel flywheel weighing twenty-six tons and running with a peripheral velocity of over 15,000 ft. per min. There is, therefore, about 55,000 ft. tons stored in the flywheel, and when its speed is reduced from 375 to 300 revs. per min., which occurs when the load from the mill comes on, very nearly half of this energy becomes available. Indeed, with the reduction in speed already specified, an output of 8,000 h.p. could be obtained for a few seconds from the flywheel alone.

The smoothing effect of this motor generator, with its heavy flywheels, will be apparent from the fact that when rolling 14-in. girders, the input to the motor generator varies from 400 to 1,200 h.p., but the output to the mill varies from zero to 7,000 h.p. The mill has been operated for almost a year by the engineman who formerly operated the steam plant, and it appears that the working expenses are 10 per cent. less.

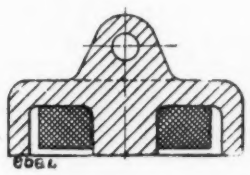


FIG. 2.—SECTION OF LIFTING MAGNET

There are in these works 20,000 h.p. of electric motors driving large and small mills.

Another application of electric power in ironworks, which is meeting with favour, is the use of electro-magnets to lift masses of iron and steel. This consists of an electro magnet of a section as shown in Fig. 2, where the iron of the magnetic circuit completely encloses the windings, and so protects them from

FIG. 3.—CANTILEVER CRANE USING AN ELECTRO MAGNET FOR STACKING PIG IRON.

injury. Such magnets enable labour on the ground to be largely dispensed with, as slinging the load is unnecessary, the magnet being energised as soon as it is lowered on the load, when it picks it up. Fig. 3 shows a cantilever crane in Messrs. Connals pig iron store at Middlesbrough, stacking pig iron, using an electro magnet similar to that shown (Fig. 2), instead of a hook and sling.

The crane will lift two and a half tons of pig iron over a radius of 60 ft.

Electric Power in Spinning Mills.

In our issue of January, 1906, we referred to the introduction of electric driving in one or two British cotton spinning mills. Some additions have now to be made, and it appears that the expectation of increased output then suggested has been realised, in that those electrically driven mills in operation have increased their output by 7½ to 12 per cent., due to the even turning effort of the electric motors. It does not appear that there is any economy in fuel, but the increased output is equal to having a working year of thirteen and a half months. In other words, an electrically-driven mill will produce as much in a year as any steam-driven mill will do in thirteen months, with no additional labour costs.

The new electrically-driven mills are The Thor Spinning Company, Whitworth, 90,000 mule spindles; the Ark Spinning Company, Bredbury, 60,000 ring spindles; the Falcon Spinning Company, Limited, Helliwell, 82,000 mule spindles. Polyphase motors are used in all cases, and steam turbines are being installed to drive the generators. The "Thor" mill is installing two "Willans" turbines and "Siemens" polyphase generators, each of 500 kw. capacity. Although the normal capacity of these turbo-generators is 500 kw., each is capable of working up to 100 per cent. overload for some hours, so that should a set become disabled the mill can be run at full power till closing time.

At the Falcon and Ark mills Fraser and Chalmers' steam turbines driving Siemens' alternators of 400 kw. capacity are installed with "Klein" condensers.

Vacuum is important in turbine plants, and the condensing plants have been arranged to give 28½ ins. of vacuum.

Another feature of these mills is that the new metallic filament lamps are used throughout. Tantalum lamps being fitted, run in groups of three and five in series.

New Watertight Fans.

Great difficulty is frequently experienced in removing air from positions in which the fan must of necessity be working in a very high temperature. Steam fans not being permissible on account of noise, the only remaining course is to use electric fans specially designed to work satisfactorily in high temperatures. Messrs. J. Gibbs & Sons, Liverpool, have produced a machine capable of working well under these conditions, the general appearance and design of which may be gathered from the illustration on p. 366. One of these machines, we are informed, has been in use on the White Star Line ss. *Baltic* for the past eighteen months, working in a temperature of 190°F., removing steam from the galley, whilst others in use by the same company are working satisfactorily in a temperature of no less than 200°F., which facts, we think, speak volumes for the design and workmanship of these machines, as it had been previously thought practically impossible to produce electric motors to work in such high temperatures without risk of breakdown.

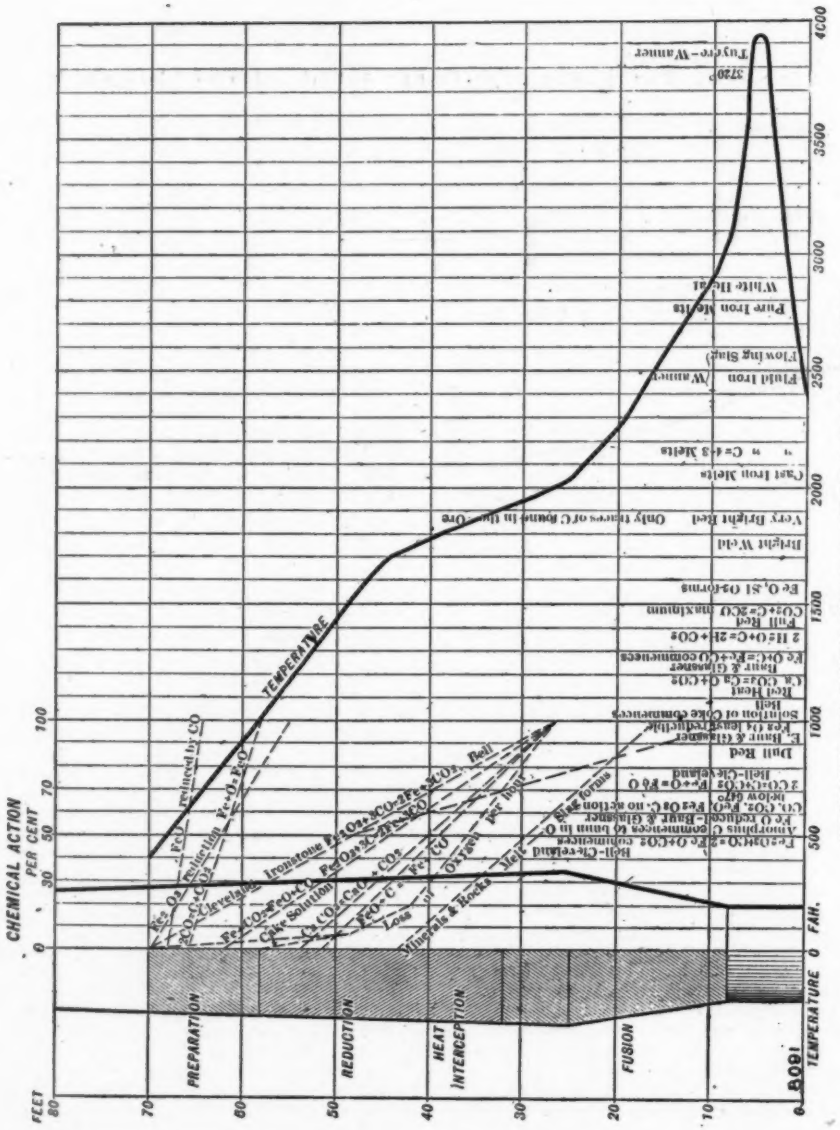
The machines are the firm's patent watertight type, driven by entirely enclosed watertight motor, specially constructed to withstand either high temperature or damp steamy atmosphere.

IRON, STEEL, AND THE FOUNDRY.

Conducted by PERCY LONGMUIR.

BLAST FURNACE PRACTICE.

Recent Modifications in Blast Furnaces.—Mr. J. Kennedy in his presidential address to the Engineers' Society of Western Pennsylvania touched on various questions of blast furnace practice, such as improvements in construction, the development of the closed top and the elimination of danger from slips. Taking the last aspect, it is shown that the introduction of a portion of fine and dusty Mesabi ore into the charge develops a tendency to interfere with the free passage of the blast through the furnace, thereby leading to irregularity with subsequent hanging and slipping. When a furnace is hanging, especially if it stops moving for some time, the stock below burns out and leaves a cavity. After the cavity reaches a certain size, its arch is liable to break, thus allowing the stock to drop. At the same time the compressed air in the cavity is released and rushes up through the falling stock. With certain forms of construction this rush of gases is liable to lift the hopper and cone or perhaps to throw them entirely off the furnace. To prevent the upheaval of bell and hopper, so-called explosion doors were placed on the downcomers, and in some cases extra openings were carried out through the casings and additional relief doors fitted. In the case of heavy slips, where heavy pressures and large volumes of blast are used, the upward rush of the blast picks up ore and coke, ejecting it through the relief doors in large quantities. It is not unusual to see from thirty to fifty tons of material thrown out in less than as many seconds, whilst at the same time a vast cloud of gases and ore dust envelop the top of the furnace. In devising a method to prevent the loss of life and damage caused by these violent ejectments, Mr. Kennedy came to the conclusion that there was no good reason why the explosion doors should not be omitted. Really there is no explosion, but the material thrown out is carried up by the rush of blast in the same manner that dust or grain is carried in a pneumatic conveyor. The fact that bells and hoppers were thrown off furnaces by slips appeared to indicate high pressures, until, on calculating the pressure required, the author was not able to find a furnace in the United States whose top would not be lifted by a pressure of 2½ lbs. per sq. in. After considerable thought, the opinion reached was that the ultimate pressure which could be produced in the top of the furnace following a slip would be the pressure in the blast mains, or, in other words, that the pressure in this case comes from the blast engines, and that the stream cannot rise higher than its source. It also seemed that if the furnace casing were of sufficient strength to resist this pressure, it would be safe to reduce the size of the outlets to such an extent as to offer material resistance to the flow of gases from the furnace in the event of a sudden and heavy rush of blast through the furnace. Such a choking of gas at the outlets would diminish the rapidity of flow for the moment and thereby reduce the tendency to carry solid materials out of the furnace. The first furnace embodying these ideas was built at the Iroquois Iron Company's Works, Chicago, and although various disasters were foretold, none of them came true. The furnace stood the heaviest of slips, and a slip that on an ordinary furnace would have thrown out twenty tons or more of stock, would not throw 300 lbs. into the dust catcher. The fact that the rush of gases is controlled to a certain extent, also causes less disarrangement of the stock in the furnace so that with a slip of a given magnitude there is less disarrangement of the working of the furnace, and less tendency to change the grade of iron made. A number of furnaces built on these lines are now in operation, and they have clearly demonstrated that it is absolutely safe to altogether close the top



TEMPERATURE AND CHEMICAL CHANGES IN THE ZONES OF A BLAST FURNACE

of the blast furnace, and that the letting loose of great volumes of dust and lumps of stock at this point is entirely unnecessary.

The Economical Production of Pig Iron.—In a recent issue of the *Iron Trade Review*, Mr. Horace Allen commences a series of articles based on a study of conditions existing in the blast furnace. Practically the first article is summarised in the appended chart, showing in a diagrammatic form the temperature and chemical changes occurring in the zones of a blast furnace. An earlier diagram by the same author has been previously noted in this section, but the present one has been amended and corrected by recent data.

Dry Air in Ore Reduction.—Desiccated blast has, on various occasions, been freely noted in this section, still in view of its inherent possibilities a recent article by Dr. Hart in the *Mining World*, demands some notice. After noting the injurious effect of moisture present in air employed in ore reduction, the author passes on to a consideration of its general effect in lessening efficiency. The general conclusion reached is that wherever air is utilised mechanical refrigeration is an economic process. In the well-known "Isabella" furnace experiments the quantity of moisture removed from the air was about four grains per cubic foot and the air was cooled from 80° to 28°F. The air handled was 34,000 cubic feet per minute and about 19 lbs. of water were removed. The results obtained showed that with natural blast the furnace produced about 360 tons of pig iron with 2,100 lbs. of coke per ton of output. With air blast dried by mechanical refrigeration, the production increased to 450 tons of pig iron with a coke consumption of 1,700 lbs. per ton of output. Less air was required, and the blowers were slowed down about 20 per cent. reducing the air handled about 15 per cent. The great saving was in the horse-power of the blower, which was reduced from 2,700 to 2,000, showing a saving of 700 h.p. The refrigeration required was about 260 tons per day. This was equivalent to the melting of so much ice, and required about double the horse-power in operating. Thus the saving in power from the blowers was more than sufficient to operate the refrigerating machine and a saving of about 200 h.p. over and above this. To this must be added the increased production and diminished cost. The total investment for the plant was between $150,000 and $200,000, which means an increased cost in production of less than 20 cents per ton.

Blast Furnace Accident.*—The distressing accident to a blast furnace of the Jones and Laughlin Steel Co., reported in the daily press on January 10th, has been investigated before a coroner's jury, who find that all known precautions had been taken to insure safety, and that the explosion was accidental. The following details, extracted from the evidence of Mr. E. L. Messler, blast furnace superintendent, are of interest. The furnace stack was built with a theoretical capacity of 600 tons per twenty-four hours. It is 100 ft. in height, has a bosh diameter of 22 ft., hearth 15 ft., and is 15 ft. in diameter at the top. The shell was reinforced with twelve steel bands, each 7½ by 1¼ ins.

The furnace burst its ninth band while being tapped on January 9th, 4½ ladles having been filled before the accident occurred. The rivets holding some of the nine bands were sheared by the force of the explosion, while others were broken at points where the stress proved greatest. Previous to relining in 1904, the best record established by this furnace was 698 tons in twenty-four hours. Since that time the output has never exceeded 600 tons, and the furnace has not been worked up to its full capacity. The furnace was not overloaded because of the fact that it was built theoretically to carry its burden. The average pressure was about 17 to 19 lbs., and it was stated that not for four years had the pressure cards indicated that 26 lbs. had been applied. There were about 800 tons of stock in the furnace at the time of the accident, and the burden carried 84 per cent. Mesabi ore. Five minutes before the accident a hang was discovered which prevented the charge from moving downwards in the furnace. The pressure was reduced, which permitted the hang to slide down, and was later increased. Finally, the witness expressed the opinion that the accident was a rare one, and according to his theory there must have been two hangs, one of which slipped when the blast was reduced and the other unknown. The evidence of various experts is also reported, but in no case has any light been thrown as to the actual cause of the accident.

Pig-Iron Statistics.—Reports to hand show the following outputs of the three chief iron-producing countries for the year 1906:—

	1905. Metric tons.	1906. Metric tons.
United States ...	23,340,258 ...	25,712,106
Germany	10,987,623 ...	12,478,267
Great Britain ...	9,746,221 ...	10,311,778

* *Iron Trade Review*

The Mineral Production of Canada.—The Mines Branch of the Geological Survey of Canada has issued a preliminary statement of the mineral production of the Dominion for 1906. A series of interesting figures result, showing in a very clear manner the metallurgical position of this promising country. Taking iron only, the total production of pig-iron in 1906 amounted to 598,411 short tons, as compared with 525,306 tons in 1905, an increase of over 13 per cent. This production represents the output of nine companies operating fifteen blast furnaces. Of these furnaces three use charcoal as fuel and twelve are run on coke.

FOUNDRY PRACTICE.

Cost Keeping.—At a meeting of the Pittsburg Foundrymen's Association, held in the early part of March, methods of foundry costing were discussed. Part of this discussion represents a table presented by Mr. W. A. Bole of the Westinghouse Machine Co., showing the method of splitting up the foundry pay roll and obtaining the relative cost per cent. of the various classes of wage labour. This table, covering the twelve months of 1906, is as follows:—

	Per cent
Wages of moulders	35·7
Wages of helpers	7·4
Coremaking	12·8
Melting, including all the labour engaged at the cupola and in the yard	3·2
Day and night labour	6·9
Chippers and cleaning castings	7·0
Miscellaneous labor	3·6
Shipping	1·5
Wages of men employed in the light and power departments...	2·0
Wages of men engaged in renewals and repairs to power plant	0·3
Wages for repairs and renewals to foundry flasks	3·3
Wages for repairs and renewals to cranes	0·6
Wages of foundry foremen and clerks ...	6·7
Wages of blacksmith and helper for bar iron work and work on chaplets, etc. ...	0·4
Wages of laborers	0·3
Wages of superintendent and clerks ...	4·0
Electric crane operators	3·7
Lavatory attendants and yard labor ...	0·6
Total	100·00

Melting Cast Iron. — A paper by Mr. Geilenkirchen, before the Vereins Deutscher Eisenhüttenleute, and issued in Stahl und Eisen, deals with the use of air furnaces instead of cupolas, especially in malleable iron foundries. Pig-iron can be melted in the cupola with 10 per cent. of its weight of coke, but in the air furnace will require 30 per cent. of its weight of soft coal. Allowing for the difference in price between coke and coal, the fuel cost of the air furnace is about double that of the cupola. Therefore with the ordinary run of work the advantages lie with the cupola, but in the case of high quality castings conditions are different. The air furnace admits of the bath being held in hand, thereby allowing its composition to be regulated, especially with reference to carbon and sulphur, and it also gives at one tap a large amount of metal of uniform composition. The gas-fired open hearth furnace, although chiefly used for steel, has a field in iron foundry practice, and the author has had very successful results from a furnace of only two tons capacity. Such furnaces, well constructed and properly worked, will run for a year at the rate of three charges per day without shutting down for repairs. The drawback is that, owing to intermittent working, fuel costs are relatively high, a feature which would vanish if the furnace could be arranged to work continuously.

The Characteristics of Foundry Iron.—In a paper read before the Birmingham branch of the British Foundrymen's Association, Mr. G. Hailstone reviews the metallurgy of cast iron in its relation to foundry practice. In the first place the structures of cast irons are described and illustrated by photo micrographs. The range of irons used in foundry practice are indicated and the following analyses given as indicating typical irons used in the Birmingham district:—

As showing the variation in separate deliveries the author quotes a South Staffordshire No. 3 iron of the same brand which over a period of three months varied within the following limits:—Silicon from

Brand of Iron.	Graphite.	Combined Carbon.	Silicon.	Sulphur.	Phosphorus	Manganese.
IXL No. 5, Cold Blast	3·270	—	1·85	0·08	0·39	0·75
Barrow Hematite, No. 3	3·44	0·16	1·85	0·04	0·05	0·79
Denby, No. 3	2·98	trace	2·67	0·06	1·45	0·35
Hatherton, No. 3	3·26	0·21	3·15	0·05	1·12	0·76
Brightside (refined iron)	2·14	0·85	1·44	0·06	0·14	0·36
Madeley Wood (cold blast)	2·28	0·72	1·26	0·05	0·76	1·29
Harrington Hematite	2·44	1·04	1·82	0·06	0·04	0·14
Stanton, No. 3	3·31	0·20	2·80	0·04	1·20	0·72

2·3 to 4·66 per cent., phosphorus from 1·0 to 1·4 per cent., and sulphur from 0·035 to 0·085 per cent. These variations sufficiently emphasise the fact that for good work each separate delivery should be analysed. The method of sampling for analysis, advised by the author is to take a half pig from every five tons of iron and drill it from top to bottom through the centre. The following table is given as suggesting the relation that should exist between the thickness of metal in the body of a casting and the chemical composition of the iron from which it should be poured.

Thickness of metal in body of casting.	Silicon.	Sulphur.	Phosphorus.	Manganese.
0·25 inches	2·70	0·05	1·0	0·4
0·50 ,, ...	2·40	0·06	1·1	0·4
0·75 ,, ...	2·40	0·07	1·2	0·5
1·00 ,, ...	2·00	0·08	1·0	0·6
1·50 ,, ...	1·75	0·10	0·8	0·7
2·00 ,, ...	1·50	0·11	0·75	0·7
2·5 to 3·0 inches ...	1·25	0·12	0·60	0·8

Pig Iron Specifications and Samplings from a Maker's Point of View.—Before the Birmingham branch of the British Foundrymen's Association, Mr. H. Pilkington ably presented another aspect as to the question of grading by fracture or analysis. At the outset, emphasis was laid on the fact that grade and grain were the matters of greatest importance in the pig iron trade. To deal in pig iron by analysis alone was at present impossible, for as is well known, the temperature at which the iron left the tapping hole had a great deal to do with the character of the metal. It was quite possible to make pig irons of equal composition behave quite differently, the difference being due to a change in crystallisation due to varying cooling temperatures. It must be admitted that fracture in itself was not a reliable guide to the composition of the metal, and some improved method of grading was desirable. In discovering this new method authors always failed to recognise commercial possibilities, and the fracture method could not be abandoned until a better substitute could be found. A good method used in America lay in classifying known brands by the fracture number of the silicon content. The adoption of this plan would be a definite step in advance, but it would involve a higher price for the expense of selection, and it may be well to remember that any method of selection will inevitably lead to enhanced cost.

DURABILITY OF STEEL ENCLOSED BY MASONRY.

The Mutual Life building in San Francisco was built thirteen years ago on made ground, and survived the earthquake without a structural damage. During the subsequent conflagration, however, it sustained damage sufficient to necessitate the removal of the upper six storeys. Information relative to the condition in which the metal part of the building was found has been given out by the engineer in charge of the reconstruction in the following form:—A steel frame, properly painted and buried in masonry, will not rust enough in thirteen years to affect its strength to any measurable extent. The better the steel is coated with mortar, the less it will rust. Portland cement is better than lime mortar for imbedding steel to prevent it from rusting. Unpainted iron rods buried in mortar composed of lime and a large proportion of Portland cement rust very little, certainly not enough to impair their strength. Columns should be of such cross-section that they can be thoroughly imbedded in Portland cement, avoiding a hollow column unless latticed and filled with very soft concrete.

Wherever possible, preference should be given to those shapes of steel that present the least surface to the action of the rust. If steel is not thoroughly cleaned from rust before it is painted, the paint will not greatly retard the progress of the rust. It is much easier to cover steel thoroughly with concrete than with brick masonry. If brick masonry is to be used, the bricklayer should thoroughly plaster the steel work ahead of the brick work. The quality of the paint used, though important, is not so important as surrounding every part of the steel with Portland cement. Interior columns do not rust as much as exterior columns. Cinder concrete does not injure to the slightest degree a steel floor beam that has been painted. No pipes or wires should ever be placed behind fireproofing, as they will buckle with the heat and push off the fireproofing. This building probably could have been saved intact if it had had fireproof exterior door and window frames with wire-glass and an emergency water-tank on the roof. Terra cotta blocks are not as good as concrete for fireproofing interior columns, nor do they protect the steel from rusting as well as does Portland cement concrete. Neither marble nor any of the well-known kinds of plaster will withstand heat. There is a tremendous demand for some durable material that can be worked as easily as can wood or plaster, but which will resist high temperature.

NEW MACHINERY AND APPLIANCES.

The Editor cordially invites early particulars of New Machinery, Improvements, Novelties, &c., for inclusion under this section.

150-Ton Hydraulic Crane at Elswick.

The accompanying illustration is that of a new hydraulic crane that has recently been erected at the Elswick Works of Messrs. Armstrong, Whitworth & Co. Ltd., by that firm for the purpose of lifting and placing into position on battleships and other vessels, completed heavy machinery, guns, gunhouses, &c.

The crane is of a fixed luffing type, and is capable when working with an effective pressure of 750 lbs. per sq. in. of lifting a load of 150 tons from 15 ft. below to 85 ft. above quay level, or through a total height of 100 ft. The maximum rake with this load is 99 ft., and the minimum rake 44 ft., the maximum outreach beyond the face of the quay being 74 ft. Auxiliary lifting machinery is fitted for dealing with lifts up to 25 tons, the maximum rake for this lift being 117 ft., and the minimum rake 50 ft. The range in turning is uulimited.

The pedestal is constructed of steel plates and angles and has an archway of such size as to allow of two lines of rails being laid through it. The pedestal is bolted to the foundations by twenty-four wrought-iron holding-down bolts, six at each corner. The revolving portion of the crane is carried on the top of the pedestal and turns on a ring of steel live rollers working between roller paths of cast steel, a steel central pivot being also fitted. The pillar, framing, and jib are of steel plates and angles strongly braced together.

The main lifting machinery is in two sets, each set being capable of lifting 75 tons, stop valves being provided so that each set can be worked independently of, or in conjunction with, the other set. Both are contained in the pillar and each consists of two hydraulic cylinders with rams acting on a common crosshead fitted with multiplying gear (8 to 1), guides and steel wire lifting rope of 7 in. circumference with a breaking strength of about 160 tons. Each rope is doubled over an equalising sheave near the jib head and led over the sheaves in the purchase blocks and thence by conveyance and the multiplying sheaves to fast ends on the cylinders, the arrangement being such that the 75-ton load on each of the two purchase blocks is taken on four parts of the rope. The purchase blocks are counterweighted so as to act as overhauling weights and the shackles are fitted with swivelling arrangement.

The auxiliary lifting machinery is contained in a steel framing secured to the front of the main pillar and consists of a hydraulic cylinder and ram fitted with multiplying gear (4 to 1), guides, conveyance sheaves, and steel wire rope of 7 in. circumference with a breaking strength of about 160 tons, the rope being led over a sheave on the jib head and fitted with swivel hook and overhauling weight.

The luffing machinery is placed on an inclined frame at the back of the pillar and is of the direct acting type, there being two hydraulic cylinders, the plungers of which working downwards act together on a forged steel crosshead, to the ends of which are attached the back ends of the steel luffing stays, the outer ends being attached to the jib head so that the motion downwards or upwards of the crosshead luffs the jib in and out respectively. The crosshead works on forged steel guide plates bolted to the inclined luffing frame, the guide pieces on the crosshead being fitted with gunmetal faces. An overhauling cylinder for assisting

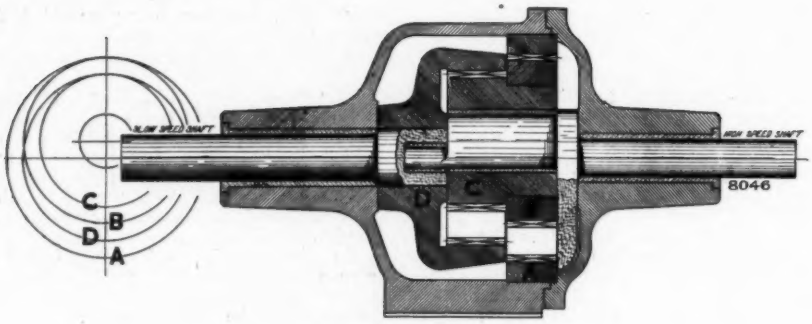
in luffing out the jib when unloaded is placed between the luffing cylinders, being fitted with ram, guides, multiplying gear (2 to 1) and two $1\frac{5}{16}$ in. overhauling chains acting on the luffing crosshead. This cylinder is always open to the hydraulic pressure when the crane is at work.

The crane is turned by a hydraulic motor of the oscillating cylinder pattern, having three cylinders and rams and actuating through spur and bevel gear, two forged steel pinions engaging with the turning rack which is bolted to the top of the pedestal. The turning machinery has two changes of gear so that the power and speed in turning can be varied to suit the load being dealt with, clutches being provided for putting either set of gear in or out of action. A brake is fitted on the turning gear.

The valves for controlling the lifting, luffing, and turning motions are fixed on the floor of the revolving platform in a house which also contains the turning motor and gearing. The levers for actuating the valves are operated from a working cabin placed above this house, near the foot of the jib.

Sufficient cast iron ballast is provided to give a reserve of stability of 50 per cent. when the full working load of 150 tons is suspended at the maximum rake.

150-TON HYDRAULIC CRANE AT ELSWICK..

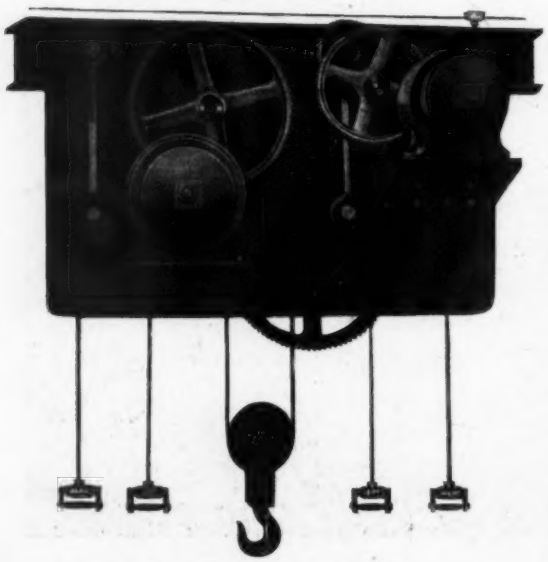


SPEED REDUCING GEAR.

Ladders and platforms are provided for giving access to the various parts of the machinery.

The crane is placed on a heavily-piled foundation, there being four groups of piles, one under each leg of the pedestal.

The crane was designed for lifting the full load at a speed of 30 ft. per min., and to make a complete revolution in turning in 1¼ min. These speeds, however, could be considerably exceeded if sufficient accumulator power is available.



4-TON MONO-RAIL ELECTRIC TRANSPORTER.

Speed Reduction Gear.

A simple form of speed reduction gear is that shown in the accompanying illustrations, and manufactured by Messrs. R. G. Ross & Son, Greenhead Engine Works, Glasgow. The high-speed shaft has a crank. Inside the casing is a fixed wheel *A*, gearing with wheel *B* which, together with the pinion *C*, works free on the crank when the high-speed shaft is set in motion; the wheel *A*, being fixed, retards the motion of *B*, thus effecting the reduction in speed.

The apparatus, which is very silent in running, is capable of being designed to give a wide range of reduction gears, having been made to effect a ratio of as high as 6133 to 1.

Among the many applications of the gear may be mentioned that to motor vehicles. In this case the fulcrum wheels are held by brakes operated by one hand lever, which controls three speeds ahead and one reverse.

Mono-Rail Electric Transporter.

One of the most recent additions to the numerous designs of small electric hoisting machinery made by Messrs. Kramos, Ltd., of Bath, is a 4-ton mono-rail electric transporter, a view of which, showing the motor side, is given in the accompanying illustration.

The apparatus consists of two mild steel plates well stayed together, to which are fixed four large flanged rollers to enable the hoist to run on a standard girder. The motor and drum for hoisting are arranged inside the plates which carry the gearing brake and controller. All the gear wheels are machine cut. In addition to the hoisting machinery a separate travelling equipment is provided, consisting of motor, gear, and controller, the parts being so arranged that the whole is evenly balanced and the load suspended almost centrally. By pulling labelled handles fitted to the controlling ropes the various motions of the hoist are actuated.

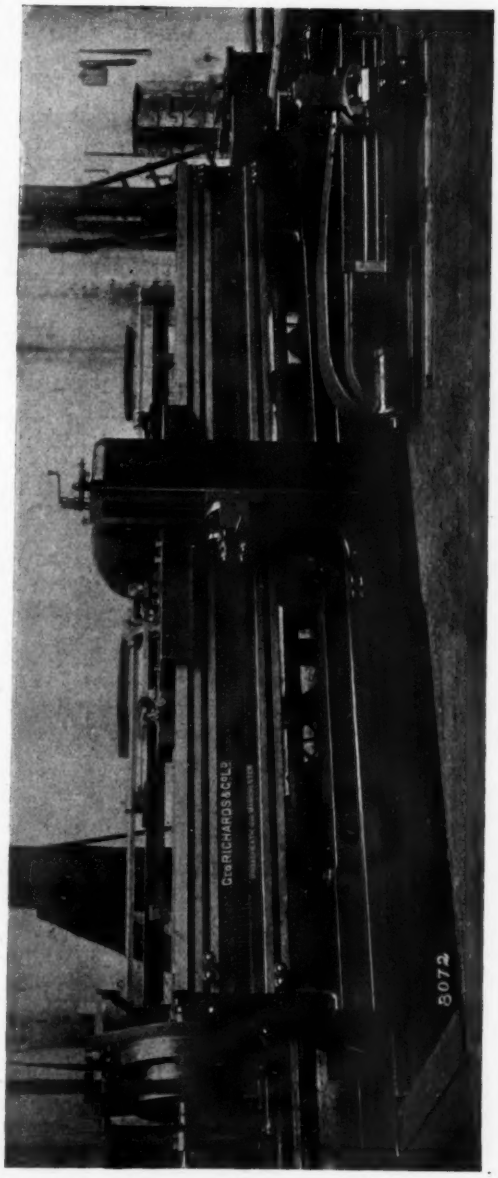
New Side Planing Machine.

The opinion which prevailed at the inception of this class of planer, that the overhanging arm would spring when the tool box was working at the extreme end of its travel, has long since been exploded, hundreds of machines being now in satisfactory use.

Messrs. Geo. Richards & Co., of Broadheath, have given constant attention to the details of construction of this tool, improvement after improvement having been made, culminating in a planer of a design that eclipses all their previous productions.

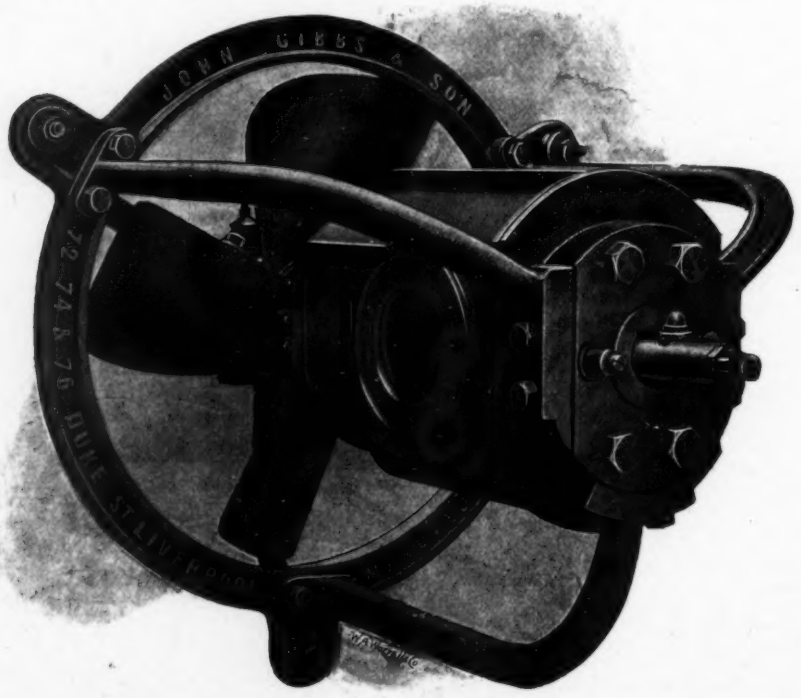
The following is a description of the machine, of which an illustration appears :—

The main feature is the substitution of a special arm for deep vertical planing for the ordinary arm, the two arms being interchangeable, one with the other. The machine planes 12 ft. long and 40 in. wide by the ordinary arm, and 12 ft. long and 4 ft. deep by the special arm, the latter having a 3 in. cross traverse, all motions being automatic. The machine is fitted with two tables. which, however, are not shown in the photograph, as these are removed from the machine when the special arm is being used, and the work mounted on a



SIDE PLANING MACHINE BY MESSRS. GEO. RICHARDS & CO., BROADHEATH.

bedplate at the front of the arm, which the users of the machine provide to suit their requirements. The vertical arm is supported at the bottom by a slide formed on the cross girth of the machine, and is fitted with a taper strip for adjustment. Hitherto the saddle carrying the overhanging arm has been guided by surfaces at the front and back of the bed, but from experiments that have been made, it has been conclusively proved that there is considerable advantage in making one shear of the bed the guiding member for the saddle. This is made perfectly clear by imagining the width of the guiding member to be increased to, say, ten times the length of the saddle. The friction in such case would be so great as to cause the saddle to lock when the cutting tool on the overhanging arm came in contact with the article to be planed. This fact has been taken advantage of in the new design, the back shear of the bed being made the guiding surface. It may appear to many that the front shear should perform this function, but when it is noted that the screw driving the saddle would be at the back of the guide, and that in this position, friction on the guiding surface is set up owing to the tendency of the screw to push the two extreme opposite corners of the saddle hard against the bed in the same direction as the thrust of the tool, it will be readily seen that by utilising the back shear for the guide, and moving the driving screw towards the cutting tool on the overhanging arm, friction on the guiding surface is considerably reduced, and less power is required to drive. Previously the saddle in length was only $2\frac{1}{2}$ times the width of the guiding member, but it is now made one-third longer, and the width of guiding member compared with the length of saddle is one to eleven. The machine is adapted for use with high speed steels, is fitted with roller bearings to take the thrust, and built up to guaranteed limits of error.



NEW WATERTIGHT FAN: MESSRS. J. GIBBS & SON, LIVERPOOL. (*See page* 356)

THE ENGINEERING PRESS.

In this section is presented every month a list of the more important articles appearing in the Engineering Press and of the leading papers read before the various engineering institutions. Full names, addresses, and published prices of the publications indexed are printed each half-year in the volume index.

Civil Engineering.

Pipe Subways in British Cities and in Paris. *Engineering News*, *14th March*, 1907.

The New York Subaqueous Tunnels, II. By C. Prelini, C.E.; The Hudson River Tunnel, New York. *Engineering*, *22nd March*, 1907.

Defective Design: As Illustrated by the Bursting of a Cast Iron Tank. By F. Southwell Cripps, C.E. *Journal Gas Lighting, &c.*, *19th March*, 1907.

The Erection of Bridges, III. *Railway Engineer*, *April*, 1907.

A study of the Stresses existing in Track Superstructure. *Engineering Record*, *23rd March*, 1907.

Strengthening Girder Bridges on the Madras Railway. By. Ed. W. Stoney. *Engineering*, *29th March*, 1907.

A Graphical Treatment of the Design of Web Plates. By E. H. Salmon, B.Sc. (Eng.). *Mechanical World*, *22nd March*, 1907.

Tunnel in the Shunting Station of the Dutch Railway Co., at Watergraafsmeer, near Amsterdam. By Ing. H. Masereeuw. *Beton u Eisen*, *March*, 1907.

Progress of Work in Lowering the Tunnels under the Chicago River. By Wm. Artingstall. *Engineering News*, *7th March*, 1907.

The Concrete Breakwater at Harbour Beach, Michigan. By Emile Low. *Engineering News*, *28th March*, 1907.

A Masonry Arch Bridge at Orleans, France. *Engineering News*, *28th March*, 1907.

Notes on Harbour Engineering. By J. R. Baterdon. *Engineer*, *5th April*, 1907.

The Entrance to the Mersey. *Engineering*, *15th March*, 1907.

Building.

Notes on the Design of New Works for Iron and Steel Manufacture. By Percival Cooke. *Mechanical World*, *22nd March*, 1907.

Reinforced Concrete Construction. By Wm. O. Ludlow. *Stevens Institute Indicator*, *January*, 1907.

Heating and Ventilation.

Ventilation of Railway Tunnels and Metropolitan Underground Railways. By C. Biraults. *Bulletin de la Societé des Ingenieurs Civils de France*, *January*, 1907.

Materials and Measurements.

The Hard Woods of Western Australia. *Engineer*, *22nd March*, 1907.

Experiments on Materials for Cold Springs Dam, Umatilla Irrigation Project, Oregon. *Engineering News*, *7th March*, 1907.

The Laws of Proportioning Concrete. By W. B. Fuller and S. E. Thompson. *Proceedings American Society Civil Engineers*, *March*, 1907.

The Calorific Conductibility of Concrete and its Resistance to Fire. *Le Génie Civil*, *6th April*, 1907.

Boilers, Furnaces, and Fuel.

Modern Steam Traps (*concluded*). *Practical Engineer*, *22nd March*, 1907.

Modern Power Gas Producer Practice and Applications. By Horace Allen (*continued*) *Practical Engineer*, *15th* and *29th March*, 1907.

Steam and Exhaust Pipes. Some Considerations of their Arrangements and Defects (*continued*). By R. McGregor. *Electrical Times*, *14th* and *21st March*, and *4th April*, 1907.

Smoke Prevention in Factories and Electric Supply Stations. By John B. C. Kershaw. *Journal Society of Arts*, *22nd March*, 1907.

Heaters for Hot Blast and Ventilation. *Machinery*, *March*, 1907.

Records of Smoke. By J. Swinburne. *Times Engineering Supplement*, *20th March*, 1907.

Engines and Motors.

A Diesel Engine Station. *Electric Engineering*, *28th March*, 1907.

Gauging a Cylinder. *Mechanical World*, *29th March*, 1907.

The Kerr Steam Turbine. *Engineer, Chicago, 1st April*, 1907.

The Thermal Efficiency of Internal Combustion Engines. By H. E. Wimperis. *Times Engineering Supplement, 20th March*, 1907.

Hydraulics and Compressed Air.

Pumping Machinery; Some Examples of Present Practice. By Ed. C. R. Marks, III., IV, *Practical Engineer, 15th March*, and *5th April*, 1907.

High Pressure Elevator Equipment of the Metropolitan Life Insurance Building, New York. *Engineering Record, 23rd March*, 1907.

Economical Production of Compressed Air. *Machinery, March*, 1907.

Losses of Work in a Compressor because of Clearance and the Effect of Design in Curtailing these Losses. *Engineer, Chicago, 1st April*, 1907.

On the better utilisation of Cataracts. *La Houille Blanche, February*, 1907.

Shop Equipment and Practice.

Roughing and Finishing Spring Screw Dies. *Machinery, March*, 1907.

Modern Shop Practice from an Inspector's Standpoint. By D. W. McNaugher. *Proceedings Engineers' Society, Western Pennsylvania. February*, 1907.

Machine Tool Design, XXXI. By Prof. J. T. Nicholson and Dempster Smith. *Engineer, 15th March*, 1907.

Miscellaneous Mechanical Subjects.

A New Wire Coiling Machine for Use in Wire Drawing Mills. *Iron and Coal Trades Review, 22nd March*, 1907.

A Recording Calorimeter for Explosions. By Prof. Bertram Hopkinson. *Engineer, 29th March*, 1907.

Lubrication of Transmission Rope. *Engineer, Chicago, 1st April*, 1907.

Keps. By James Tonge. *Iron and Coal Trades Review, 5th April*, 1907.

Rolling of Sheet Steel for Tin Plates. *Practical Engineer, 15th March*, 1907.

Drying Transformer Oil. By R. B. Treat. *Electrical World, New York, 2nd March*, 1907.

The Engineering of a Country House, II. *Engineer, 15th March*, 1907.

Nomogramme for the Calculation of Screw-Shaped Cylindrical Springs. By Fritz Krull. *Le Génie Civil, 6th April*, 1907.

Railway and Locomotive Engineering.

The Locomotive Front End. By Geo. T. Clayton. *Mechanical World, 5th April*, 1907.

Flexible Firebox Stays. *Railway Engineer, April*, 1907.

Track Deformations and their Prevention. By G. Cuenot. *Railway Gazette, 29th March*, 1907.

Steel Passenger Car, N. Y. C. & H. R. R. R. *American Engineer and Railroad Journal, March*, 1907.

Welding Frames with Oil. By C. J. Morrison. *American Engineer and Railroad Journal, March*, 1907.

Instructions to Govern the Use of Coke on Locomotives. B. & O. R. R. *American Engineer and Railroad Journal, March*, 1907.

Locomotive with Baldwin Superheater, P. S. & N. R. R. *American Engineer and Railroad Journal, March*, 1907.

Cast Steel Crank Axles and Rods. Northern Railway of France. *American Engineer and Railroad Journal, March*, 1907.

The New York Central Accident Investigation, and the Action of Railway Trains on Curves. *Engineering News, 7th March*, 1907.

Automatic Railway Couplings. *Railway Gazette, 5th April*, 1907.

Track Deformations and their Preventions. *Railway Gazette, 5th April*, 1907.

Adjusting Stevenson Valve Gear. By James Kennedy. *Railway and Locomotive Engineering, March*, 1907.

Metre-Gauge, Royal Train for India. *Engineering, 15th March*, 1907.

Great Western Railway Standard Signals. *Railway Gazette, 15th March*, 1907.

Rail Corrugation. By J. A. Panton. *Proceedings Institute of Electrical Engineers, 21st March*, 1907.

Motor Engineering.

Considerations in the Design of a Four-Cylinder Motor Car (*continued*). *Practical Engineer, 22nd March*, and *5th April*, 1907.

On some Points in the Action of a Magneto. By W. Hibbert. *Automobile Club Journal, 14th March*, 1907.

Problems of the Motor Industry. By V. B. Lewes. *Automobile Club Journal, 21st March*, 1907.

Lubricants for Motors. *Autocar, 23rd March*, 1907.

The Smoke Emission Trials. Description of the Competing Devices and the Tests to which they were subjected. *Autocar, 23rd March*, 1907.

The Darracq-Serpollet Steam Bus. *Automotor Journal, 6th April*, 1907.

The Strength and Structure of Alloys. By W. Rosenhain, before Institution Automobile Engineers. *Autocar, 6th April*, 1907.

The Design of Petrol Engines for Motor Cars, V., VI. *Mechanical World, 15th March* and *5th April*, 1907.

The Scientific Regulation of Traffic. By Earl Russell. *Automobile Club Journal, 28th March*, 1907.

Alcohol - Acetylene. A Combined Fuel for Motors. *Autocar, 30th March*, 1907.

The 10 h.p. Bolsover Steam Car. *Automotor Journal, 16th March*, 1907.

The B. T. H. Petrol Electric System for Commercial Vehicles. *Electrician, 15th March*, 1907.

Conditions which establish the interchangeability of the chassis. *La Locomotion Automobile, 23rd March*, 1907.

The Mangement of Automobiles. *La Locomotion Automobile, 6th April*, 1907.

Definitions of the operations applied in the manufacture of the parts of automobiles. *La Locomotion Automobile, 16th March*, 1907.

The Horse Power of the Petrol Motor in its Relation to Bore, Stroke, and Weight. By F. W. Lanchester. *Proceedings Institute of Automobile Engineers, 10th April*, 1907.

Electric Lighting.

The Verity-Dalziel System of Train Lighting. *Electric Review, 29th March*, 1907.

Flame Arc Lamps. By H. S. Hatfield. *Electrician, 15th March*, 1907.

Electrical Generation and Transmission.

A new type of Induction Motor. *Electrical Engineering, 4th April*, 1907.

The Westinghouse Continuous and Single Phase Unit Switch Multiple Control Systems. *Electrical Engineering, 4th April*, 1907.

Extra-High-Tension Switch Gear. *Engineering, 29th March, 5th April*, 1907.

Pressure Rise on High-Tension Transmission Lines. By E. Hudson. *Electrical Engineer, 22nd March*, 1907.

Motor Starting Rheostats. By Geo. T. Hanchett. *Electric World, N.Y., 23rd March*, 1907.

Underground Transmission and Distribution of Electrical Energy. By Chas E. Phelps. *Proceedings American Institution Electrical Engineers, February*, 1907.

High Tension Outlets. By Alvin Meyers. *Proceedings American Institution Electrical Engineers, February*, 1907.

Localization of faults on a Three-Wire Network. By F. Fernie. *Electrical Review, 15th March*, 1907.

Calculation of the Leakage—Reactance of Induction Motors. By J. E. Hanssen. *Electrical World, N. Y., 30th March*, 1907.

Some Historical Notes on Continuous Current Series Systems. By H. M. Sayers. *Electrical Engineering, 21st March*, 1907.

The London Power Problem. *Times Engineering Supplement, 13th March*, 1907.

Transmitters for Electro-Magnetic Waves. By Dr. Johann Sahulka. *Elek. u. Maschinenbau, 7th April*, 1907.

Electric Traction.

Some Facts and Figures bearing on the Bronx Park Derailment on the New York Central. *Engineering News, 14th March*, 1907.

The Johannesburg Electric Tramways. *Electric Review, 5th April*, 1907.

The Electrification of Steam Railways from the operating point of view. *Electrician, 29th March*, 1907.

Transit Facilities in New York, V., VI., *Engineer, 15th* and *29th March*, 1907.

Power Signalling as installed by the Underground Electric Railways Co., of London. By B. H. Peter. *Electric Review. 15th* and *22nd March*, 1907.

The Dolter Surface-Contact System. Its application to Tramways at Torquay, Mexborough, and Hastings. *Tramway and Railway World, 7th March* 1907.

The Inter-Pole Railway Motor. By C. A. Mudge. *Electrical World, N.Y., 9th March*, 1907.

The Renard and Sourcouf Road Train System. By B. H. Thwaite. *Transactions Society Engineers, 8th April*, 1907.

Lecture on Single Phase Traction. By W. S. Murray. *Street Railway Journal, 30th March*, 1907.

The Strain on Curve Spikes. *Street Railway Journal, 30th March*, 1907.

State Electric Goods Railway in Deuben. By J. Schauer. *Elek. Kraftbetriebe u. Bahnen, 4th April*, 1907.

Single Phase and Continuous Current Railway Electrification. By H. M. Hobart. *Times Engineering Supplement, 10th April*, 1907.

Miscellaneous Electrical Subjects.

The Electrical Equipment of Palmer's New Cableway. *Electrician, 5th April*, 1907.

Electric Beam Balancing Device for Testing Machines. *Electrical Engineer, 5th April*, 1907.

Electrical and Chemical Energy. By G. M. Westman. *Journal Franklin Institute, March*, 1907.

The Depreciation of Underground Cables. By F. Fernie. *Electrical Review, 5th April*, 1907.

The Kuhlo System of Wiring with Sheathed Conductors. By M. Biske. *Electrician, 5th April*, 1907.

Uniformity in the Design of Electrical Machinery. *Electrical Review, 22nd March*, 1907.

Calculations of Auxiliary Pole Windings. By A. Keller. *Electrical World, N.Y., 9th March*, 1907.

Some Theoretical Notes on the Reduction of Earth Currents from Electric Railways by means of Negative Feeders. By Geo. J. Rhodes. *Proceedings American Institute Electrical Engineers, February*, 1907.

Electrolytic Corrosion of Iron and Steel in Concrete. By A. A. Knudson. *Proceedings American Institute Electrical Engineers, February*, 1907.

Alternator Troubles. By A. E, Buchenberg. *Electrical World, N. Y , 2nd March*, 1907.

Elimination of Instrumental Error in Resistance Instruments. *Western Electrician, 23rd March*, 1907.

A Comparison of Steam and Electrical Winding Engines. *Engineer, 5th April*, 1907.

Alternating Current Electrolysis. By J. L. R. Hoyden. *Proceedings American Institution Electrical Engineers, February*, 1907.

Experiences with Electric Cooking. *Electrical World N. Y., 2nd March*, 1907.

The Electrical Driving of Cotton Mills. *Electrical Engineering, 14th March*, 1907.

Standard Cells. By K. E. Guthe and C. L. Von Ende. *Physical Review, February*, 1907.

Marine Engineering and Naval Architecture.

The Screw Propeller. By A. E. Seaton IX. *Marine Engineer, 1st April*, 1907.

Sterns and Stems of Motor Boats. *La Locomotion Automobile, 30th March*, 1907

Oil Fuel on Shipboard. By Mr. Graydon Hume. *Steamship, April*, 1907.

Villinger's Patent Reversible Propeller. *Steamship, April*, 1907.

The Towing Resistance of a Floating Dock. By H. A. B. Cole. *International Marine Engineering, April*, 1907.

The Railway Type of Dry-Dock. By J. L. Crandall. *International Marine Engineering, April*, 1907.

The Influence of Machinery on the Gun Power of the Modern Warship. By J. M'Kechnie. *Proceedings Institute of Naval Architects, March*, 1907.

Safe Submarines and the Future of the Art. By Simon Lake. *Proceedings Institute of Naval Architects, March*, 1907.

On some Points of Interest in the Construction and Launch of the *Lusitania*. By W. J. Luke. *Proceedings Institute of Naval Architects, March*, 1907.

The Evolution of the Modern Cargo Steamer. By S. J. P. Thearle. *Proceedings Institute of Naval Architects, March*, 1907.

Cranes for Shipbuilding Berths. By Signor C. Piaggio. *Proceedings Institute of Naval Architects, March*, 1907.

Torsiometers as Applied to the Measurement of Power in Turbine and Reciprocating Engines. By Archibald Denny. *Proceedings Institute of Naval Architects, March*, 1907.

Torque of Propeller Shafting: Some Conjectures, Investigations, and Results. By J. Hamilton Gibson. *Proceedings Institute Naval Architects, March*, 1907.

Propeller Struts. By G. Simpson. *Proceedings Institute Naval Architects, March*, 1907.

Experiments with Dr. Schlick's Gyroscopic Steadying Apparatus, By Sir William H. White, K.C.B. *Proceedings Institute Naval Architects, March*, 1907.

Approximate Formulæ for Determining the Resistance of Ships. By A. W. Johns. *Proceedings Institute of Naval Architects, March*, 1907.

The Application of the Integraph to Ship Calculations. By J. G. Johnstone. *Proceedings Institute of Naval Architects, March*, 1907.

The Prevention of Fire at Sea. By Prof. Vivian B. Lewes, F.I.C., F.C.S. *Proceedings Institute of Naval Architects, March*, 1907.

Modern Floating Docks. By Lyonel Clark. *Proceedings Institute of Naval Architects, March*, 1907.

Some Phases of the Fuel Question. By Prof. Vivian B. Lewes, F.I.C.. F.C.S. *Proceedings Institute of Naval Architects, March*, 1907.

Sewage.

Streets and Pavements.

Experience with Various Pavements on Streets with Heavy Grades. By C. G. Anderson. *Engineering News, 14th March*, 1907.

Tarring Macadam Roads in Chicago. *Journal of Gas Lighting, &c., 2nd April*, 1907.

Water Supply.

Some new Facts Relating to the effect of Meters on the Consumption of Water. By W. S. Johnson. *Engineering News, 28th March*, 1907.

The use of Lactose Bile Media in Water Analysis. By D. D. Jackson. *Engineering News, 14th March*, 1907.

Engineering Economics and Works Management.

The Establishment of a Piece-work System II., III. By E. G. Fiegehen. *Mechanical World, 15th* and *29th March*, 1907.

Miscellaneous.

The Elastic Modulus for Small Loads at the Elastic Limit. By H. W. Pearce. *Physical Review, February*, 1907.

Electric Furnace Methods of Iron and Steel Production. By John B. C. Kershaw, V., VI. *Electrician, 22nd March*, and *5th April*, 1907.

Researches on the Forms and Stability of Aeroplanes. By W. R. Turnbull, M. E. *Physical Review, March*, 1907.

Glass and its Manufacture by the Electric Furnace. *La Houille Blanche, February*, 1907.

Thirty-five Kilometres Aerial Transporter between Chilecito and Upulungos, Argentine Republic. *Le Genie Civil, 23rd March*, 1907.

The Potential of Hydrogen liberated from Metallic Surfaces. By H. Nutton and H. D. Law.

Electrode Potentials in Liquid Ammonia. By N. T. M. Wilsmore and F. M. G. Johnson.

The Impedance of Solutes in Solvents as manifested by Osmotic Pressure. By John G. A. Rhodin. The Electrolytic Deposition of Zinc, using Rotating Electrodes. By Dr. T. Slater Price. *Proceedings Faraday Society, 19th March*, 1907.

The Engineer as a Citizen. By A. C. Humphreys. *Stevens Institute Indicator, January*, 1907.

The Utilisation of Labour. H. L. Gantt. *Stevens Institute Indicator, January*, 1907.

A comparision of University and Industrial Discipline and Methods. F. W. Taylor. *Stevens Institute Indicator, January*, 1907.

Reports of Committees of the San Francisco Association of the Members of the American Society of Civil Engineers on the Effects of the San Francisco Earthquake of 18th April, 1906. *Proceedings American Society Civil Engineers, March*, 1907.

The Latent Heat of Recalescence in Iron and Steel. By F. K. Bailey. *Physical Review, February*, 1907.

TRADE LITERATURE.

Thermit, Ltd., 27, Martin's Lane, Cannon Street, E.C. Pamphlet No. 5 dealing with the application of the firm's patent Alumino Thermic welding process to marine repairs. Up to the present these repairs have all been effected outside the United Kingdom, owing to our not having obtained the sanction of Lloyd's Register for this method of repair to ships under their control. The firm recently arranged to weld a sternframe, about 11 ft. by 6½ ft. in the presence of representatives of Lloyd's, the Board of Trade, and of the technical Press, at the Dry Dock of the Thames Ironworks, Shipbuilding and Engineering Co., a demonstration which was completely successful.

R. Waygood & Co., Ltd., Falmouth Road, S.E. Catalogue of hand power lifts, also three pamphlets dealing with lifts and hoists, one of which gives in eight pages, in illustrated form, an epitome of the firm's various manufactures. The sheet dealing with builders' hoists should be useful to contractors and others who require the use of such hoists in connection with their work on new buildings, &c. Attention may be called to the fact that these hoists can be hired by those who only wish to use them temporarily.

Breuer, Schumacher & Co., A. G. (Kalk), 21, Lime Street, E.C. Large bound catalogue, printed in three languages, dealing with machine tools, auxiliary machinery for metallurgical works and rolling mills, hydraulic machinery, steel works and rolling mill plants.

Liverpool Engineering and Condenser Co., Ltd., Brunswick Dock, Liverpool. Catalogue of Quiggin's patent evaporators and distilling plant, with particulars of sets supplied to the Cunard steamships *Lusitania* and *Mauretania*.

Crompton & Co., Salisbury House, London Wall, E.C. Sectional catalogues U 14 of electrical instruments for alternating current circuits, and U 15 of reflecting galvanometers, resistance boxes and other testing room appliances.

Peckett & Sons, Bristol. Well printed and illustrated handbook of the various types of locomotives constructed by this firm, containing also a fine set of views of the works.

Simplex Conduits, Ltd., Birmingham. Booklet entitled "The Real Truth about Enamel," being some notes on the protective coverings of conduits.

W. H. Bailey & Co., Ltd., Manchester. Leaflets dealing with a bell-tolling machine, tide recorder and express feed pumps.

John Taylor, Dunford & Co., Ltd., Newcastle-on-Tyne. Latest price list of belting.

MANUFACTURERS' NOTES.

The Empire Roller Bearings Co., Ltd. Among the recent orders received by this Company for their Patent Roller Bearing Axleboxes, are the fitting of twenty-five additional tramcars for the Brazilian Tramways, from the Madras Railway Co., for bearings for their main line rolling stock, a further supply for Calcutta rolling stock, and for the fitting of new cars for the Liverpool Corporation Tramways, the Great Grimsby Tramways, and additional bearings for the Lancashire & Yorkshire Railway Co.

Messrs. Ernest Scott & Mountain, Ltd., of Newcastle-on-Tyne, inform us that they are just about to open a new suite of offices in the corner building at the junction of Queen Victoria Street and Cannon Street, London. This office will be in a very central positon, overlooking the Mansion House Station, the entrance being No. 49 Queen Victoria Street, E.C. Messrs. Scott and Mountain's London business is under the care of of Mr. R. Hood Haggie, assisted by Mr. A. E. Backhouse.

Messrs. Alfred Herbert, Ltd., Coventry, report that owing to the fact of their new works having started operations, they have now to a considerable extent overtaken the excessive demand for their various tools and can now give better deliveries. They have been making experiments with the object of producing accurate and reliable hobs for gear hobbing machines and are now in a position to supple these suitable for cutting silent running gears.

Messrs. Hughes, Fawcett & Co., Hebden Bridge, advise us that they have recently purchased the business lately carried on by Messrs. Harrison & Horsley, Pomona Iron Works, Cornbrook Road, Manchester, and are transferring it to their works at Hebden Bridge, where they will continue to make the Anglo-American type of shaping machines up to 20-in. stroke, which were a speciality of the late firm.

The Lowca Engineering Co., Ltd., Whitehaven, have received instructions to build two pairs of 24-in. by 54-in. piston valve winding engines for the Moresby Coal Co., Ltd., and one 6-wheeled coupled side tank locomotive, 18-in. cylinders by 26-in. stroke, for the Consett Iron Co., Ltd., Durham.

The Beldam Packing & Rubber Co., 93—4, Gracechurch St., E.C., inform us that the H.P. rods and valve spindles of the engines of the new White Star Liner *Adriatic* are packed with their patent "Excelsior" Metallic Rings.

The Kennicott Water Softening Co., 18 & 19, Great St. Helens, received during the week ending April 15th orders for eight water softeners with an aggregate treating capacity of 113,000 gallons per hour.

The British Westinghouse Co., Manchester, are constructing a turbo-generator of 400 kw. capacity for H. M. the Czar of Russia, to light his palace at Tsarkoe Selo.

Messrs. J. Butler & Co., Halifax, have appointed as sole London representatives Messrs. J. E. Lawler & Muirhead, 39, Lime Street, E.C.

SECOND PRIZE COMPETITION FOR ENGINEERS.

WITH the object of encouraging readers of THE ENGINEERING REVIEW to communicate their ideas and experience on subjects of engineering interest,

A PRIZE OF £10

was offered for what was, in the opinion of the Editor, the best article on one of the undermentioned subjects:—1. The Relative Value of Planing and Milling. 2. Electrical *v.* Mechanical Driving. 3. Bonus Systems of Payment for Labour.

The award for the best and most practical article will be announced in the June number. Meantime we have decided to give another

PRIZE OF £10

for best article on one of the following subjects under the conditions given below:—

1. Live Steam Feed Heating.
2. Flame Arc Lamps.
3. The Management of Steam Turbines.

INSTRUCTIONS AND CONDITIONS.

Articles must not contain less than 2,000 words, and must be written on one side of the paper only, and be signed by the competitor.

Drawings and sketches must be on separate sheets of paper.

A short biographical sketch of the competitor's technical experience should accompany the article.

The right is reserved of publishing the prize article, and also any of the others sent in; but in the case of the latter, payment will be made for the same at our usual scale rates.

The Editor's decision in all matters connected with the competition shall be final, and binding on all the competitors.

All articles should be addressed to the Editor of THE ENGINEERING REVIEW, 104, High Holborn, London, W.C., and marked on the outside, "Competition," and the same must be received not later than August 1st.